CORNELL AERONAUTICAL LABORATORY, INC.
BUFFALO, NEW YORK 14221

AN EXPLORATION IN SYSTEMS ANALYSIS OF DOMESTIC CONFLICT

By: Joseph M. Firestone

CAL NO. VO-2653-G-1

CONTRACT NO. N00014-67-A-0387-0003

FEBRUARY 1969

Sponsored by:

THE DIMENSIONALITY OF NATIONS PROJECT
UNIVERSITY OF HAWAII UNDER SUBCONTRACT FROM
THE ADVANCED RESEARCH PROJECTS AGENCY,
ARPA ORDER NO. 1063
MONITORED BY THE OFFICE OF NAVAL RESEARCH

ACKNOWLEDGMENT

I am grateful for the assistance given me in performing this research by various scholars associated with the Dimensionality of Nations Project. Special thanks are due to Professors Rudolph J. Rummel and Richard Chadwick, Mr. David McCormack, and Mr. Warren Phillips. In addition I have benefited from consultation on statistical matters with Mr. James M. Moore of Cornell Aeronautical Laboratory, Inc., and from consultation with Edwin W. Roth, Robert M. Stevens, and Sol Kaufman, also of Cornell Aeronautical Laboratory, Inc. The present memorandum is a first draft of a paper to be submitted for publication. While it is expected that future drafts will include Mr. David McCormack as co-author, the present version is my sole responsibility.

Introduction

If one were to judge from the proliferation of systems language in political science in the last 15 or so years, it would seem that political systems analysts comprise one of the most numerous groups in contemporary political science. It is a rare current text that does not give some attention to systems theory. Moreover, a long series of theoretical works[1] have, since the early fifties, taught the "systems point-of-view".

In spite of what might be called General Systems Theory Socialization however, the accomplishments of political systems analysts are generally not quantitative or mathematical. For while systems analysis in Biology, Physics, and the Computer Sciences involves quantitative and mathematical disciplines, the works of such proponents of the systems approach as Almond, Easton, Riggs, Deutsch, Mitchell, and Kaplan, are primarily "Theoretical" in their expositions of systems theory. While such theoretical works have been, and undoubtedly still are useful for purposes of general research orientation, it is also true that further development in political systems theory implies research which will recast verbal systems notions in both mathematical and empirical contexts.[2]

An instance of such recasting will be recorded here. Our purpose is to present and to apply a strategy for quantitative analysis of large-scale political systems. In order to provide background, the discussion will begin with a systems analysis concept. The suggested strategy for systems analysis will then be described. Finally, the major portion of the paper will be concerned with an illustrative analysis of cross-sectional and time-series data on domestic conflict.

A Systems Analysis Concept

For present purposes it is sufficient to define a system as a conceptually isolable unit or entity. According to Rudner (1967, p. 89) "a scientific account of a system," (that is to say a systems analysis) "must include at least the following:

> 1. an identification of the components or elements of the system.
>
> 2. a specification of aspects or characteristics of the components relative to which descriptions of the states of the system are to be provided.
>
> 3. a specification of the set of laws in conformity with which states of the system succeed or precede each other, or with which elements of the system interact as regards the characteristics specified in 2."

This statement of the three essential requisites for systems analysis highlights a central characteristic of the systems approach. More specifically, its instrumental, pragmatic, and hypothetical character relative to the interests or goals of the scientist. Thus, it is the systems analyst who decides which types of entities will be construed as system components. Incidentally, the requirement of component identification does not preclude a conception of political systems as undifferentiated wholes. It is not necessary to distinguish more than one system component so long as this strategy is efficacious for theory building.[3] (In the systems analysis reported on below, systems are viewed as one component wholes.)

Similarly, it is also up to the systems analyst to specify the attributes of the components -- in other words, the variables relative to which state descriptions of the system are to be provided. These variables are called state variables because state descriptions are given in terms of them. A state description on the other hand,

> "is the minimum amount of present information about the history of the system which allows one to predict the effect of the past upon the future."[4]

State variables may be chosen in any fashion as long as they are measurable and provide state descriptions meeting the requirement just stated.[5]

Finally, it is emphasized that the laws governing transition from one time interval to another refer specifically to the state descriptions couched in terms of the values of the state variables.[6] Beyond this restriction the laws of transition may take any form,[7] though of course they must effectively account for, and allow one to predict changes in the values of the state variables (changes in state descriptions) over time.

The three requirements of a systems analysis thus themselves constitute an interdependent decision system. Components, state variables, and laws must all be specified with an eye for theory building utility relative to the specific interest of the researcher. If, for example, this interest is domestic political conflict, the analyst would identify system components or actors he thinks are involved in conflict interactions. He would then select variables applicable to these entities which he thinks are causal to, or symptomatic of, domestic conflict. Finally, he would attempt to specify relations among the state variables as the values of these change over time so that in turn he could relate changes in state variable values with changing time to changes in domestic conflict with changing time.

The most salient aspect of the decision system just outlined is the necessity for its justification in terms of the relative success or failure of the systems theory eventuating from it. Thus, strictly speaking, only hypothetical components state variables, and laws of the system causal to domestic conflict are or can be specified. Such components, state variables, and laws are only as useful as the theory in which they are imbedded.

Before leaving the subject of definition of the system concept some additional comments about hypothetical system state variables are desirable. First, it would be clear from the context of the above discussion that the role of state variables in system analysis is to describe systems at a given point in time, in other words, their states. Hence, the term state-description refers to a description of the time-frozen characteristics of system interaction at a point in time. In contrast, the laws mentioned in requirement (3) above specify the dynamic characteristics of systems -- that is, the changes in their states with changes in time.

Second, it has been indicated that state variables are chosen with an eye towards the phenomenon or phenomena that systems analysis is supposed to account for. This raises the question of the relation between that phenomenon (which is the focus of practical interest) and the state variables (which are the focus of theory construction). We here distinguish two cases. A) The phenomenon may be selected as one of the state variables itself. Thus, amount of domestic violence, for example could be selected as a state variable in a systems analysis attempting to explain its occurrence. B) The phenomenon may be connected through some functional relation to the state variable. Thus, amount of domestic conflict may be selected as a state variable, while amount of domestic violence is related to it through some expression $y = f(x)$, where y is domestic violence and x is domestic conflict.

Third, it is emphasized that the state variables selected should be the minimal number necessary for useful laws of system change to be formulated.[8] The sense of minimal intended is as follows. The state variables should be functionally independent of each other at any given point in time. That is to say, the analyst should not be able to write an expression $y = f(x)$ such that one state variable y may be expressed in terms of a second x at point in time t.[9] The reason for this is scientific economy. If one state variable could be expressed in terms of another, we could eliminate that state variable from the set of laws governing change over time in the system. This would make our dynamic laws more parsimonious.

Fourth, though state variables are functionally independent of each other at any point in time, they must be functionally dependent over time. Conventionally, the functional dependence of state variables over time is expressed in terms of the mutual dependence of all state variables on changing time.

A Strategy for Quantitative Analysis of Political Systems

The conception of systems analysis just advanced suggests the "nature" of the "strategy" for quantitative systems analysis to be presented now. No "magic formula" or "snake oil" nostrum for the problems of political scientists is possible. For quantitative systems analysis involves theoretical formulations and decisions which are peculiar to individual research circumstances. Moreover, such decisions must intertwine to produce a theoretical structure which is sound at all three of its major nodes.

Thus, the "strategy" for systems analysis to be outlined attacks this problem only at a very abstract level, and in such a fashion as to provide loose programmatic guidelines for research.

More specifically we wish to comment on the three problems of selection of system components, selection of state variables, and derivation of laws of transition from state-to-state highlighted in the preceding section.

a. System Components

The problem of selection of system components is perhaps the most crucial of the three problems highlighted earlier. This is true because a particular decision at this point has important consequences for the relative simplicity or alternatively, complexity of both state variable and time-transition analyses. A major issue here is the number of system components whose properties and static and dynamic interrelations will need to be considered. More concretely, suppose a political scientist seeking to analyze foreign political systems chooses to base his analysis on a theoretical framework which treats a large number of social actors as system components. Such a decision means that the analyst must derive state variables for each of the system components and also specify relations among state variable properties which will constitute properties of the system as a whole. (This last specification of relations among the components, by the way, is the problem of aggregating from the component level-of-analysis to the systemic level.) This last is a prohibitive task if the number of components and properties in question is appreciable. On the other hand, suppose the political scientist bases his analysis on a theoretical framework which treats only one social actor as a system component, for example the nation-state itself, while viewing the properties of other social actors as aggregate properties of the nation state. If this is done all the properties of the system in question can be expressed as one row or column of a matrix, and hence the problem of deriving state variable properties of the system as a whole is (as we shall later show) mechanically much simpler.

It may be objected, at this point, that "black-boxing" political systems while admittedly simplifying analysis does not provide one with knowledge of the inner workings of such systems, and therefore does not facilitate political systems analysis. While it is agreed that it may be of value to know the interrelations among properties of all important social actors within national political systems for some purposes it should be pointed out that for such tasks as predicting the level of domestic conflict, governmental instability, economic development, foreign trade and other such characteristics of nations it may not be necessary to adopt a systems analysis model which takes account of the interaction among system components. At least it is not clear on a priori grounds that this more complex form of systems analysis is more effective than a black-box approach for purposes such as these. Since the black-box approach is much simpler than the component-interrelations approach, it behooves political scientists, if they are so inclined, to explore the former before adopting the latter.

In sum, then, it is suggested here that political systems analysts distinguish only one component - the system itself, in most research contexts. Exceptions to this recommendation may be expedient in certain research problems involving systems which have only a few primary distinguishable components. For example, if dyadic international systems are studied the complexity of the analysis is not materially increased if nation-state components of dyads are distinguished. If nation-states themselves are studied however, the complexity of the analysis is made overwhelming if all relevant social actors are viewed as components.

b. Selection of State Variables

The remainder of the strategy for systems analysis being outlined here assumes a decision has been made to consider one as opposed to many - component systems. The recommended strategy therefore is limited to quantitative systems analysis of one-component systems, and in fact our first programmatic recommendation has been that political systems analysts should most often formulate their concepts in terms of the one-component systems idea.

Our second recommendation concerns the process of selecting hypothetical state variables. We can never insure that a set of such variables will prove a fruitful choice in the sense of leading to a highly confirmed systems theory. This is a matter of theoretical ingenuity and empirical test. We can however suggest a procedure that will help analysts to increase their chances of selection of fruitful state variables. More specifically, our suggestion is that state variables should be identified through the application of factor analysis to representative data matrices. The procedure we have in mind follows.

(1) Gather a set of raw data values on a selected set of variables j for a selected set of cases i. By a case i we mean here a set of data values applicable to a political system at a point-in-time. Such cases will be hereafter called political system-time-slices, or nation-time-slices, or actor-time-slices depending on the context of our later discussion. The term case will be reserved for reference to all the political system-time-slices of one political system or actor. (It should be noted here that no separate system components are assumed but rather a conception of the system as a collective whole.) The set of political systems-time-slices i should be a representative set relative to the values taken on by the set of data variables j. That is to say the j values of the i's must well-represent the hypothetical universe of data values the systems analyst is studying if state variables are to be derived successfully.

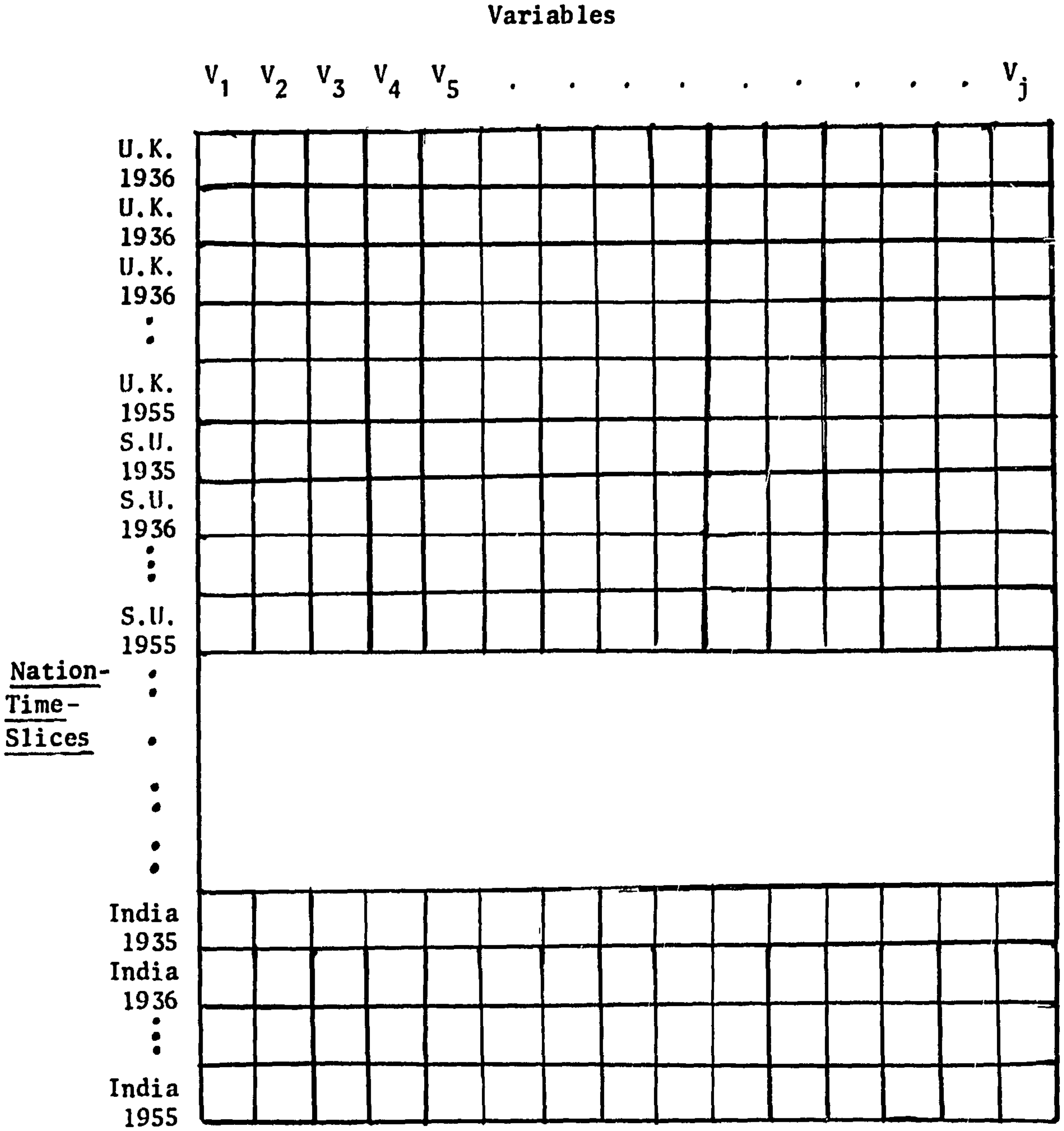

Figure 1 - Form of raw data matrix for systems analysis

(2) Next arrange the data so that the time slices i are the rows of a matrix A and the data variables j are its columns. Such a data matrix might look like the following if the systems being analyzed were nations, and the time-slices considered relevant were annual time slices spanning the period 1935-55.

Figure 1 is a representation of a data matrix containing a set of time-slices composed of values of a set of data variables characteristic of a set of nations. The figure illustrates an important aspect implied above, of the method being outlined here. This is that the method prescribes analysis of a data matrix that is representative of variation through space and time of data values relative to nation-time-slices. The purpose of such an analysis is to form generalizations relating data variables to state variables. Values of both data and state variables however, are localized in nation-time-slices. Hence the generalizations in question are about such time-slices and it is necessary to employ a representative set of these, (as depicted in Figure 1) as the object of an analysis which seeks generalizations relating data and state variables.

More specifically, in terms of matrices of the type presented above, this means for example that the set of U.K., S.U., India, and other nation-time-slices considered representative are all analyzed within the same matrix. In other words both cross-sectional and longitudinal data are analyzed simultaneously. This is contrary to the most common practice in the social sciences which is either a) to analyze time-slices of different actors where each actor-time-slice refers to the same point in time (for example, a data matrix of all nations for 1955), or b) to analyze time-slices of the same actor where each actor-time-slice refers to a different point in time (for example, a data matrix of annual data values for the U.S.A. from 1935-65).

It must be emphasized again therefore that the above approach is justified by its purpose which is to provide the best possible basis for generalizations about political systems-time-slices and the relation of data variables to state variables within these. The more commonly used cross-sectional and longitudinal approaches do not provide as good a basis for these generalizations as the above because the number and scope of political system-time-slices provided by the more conventional approaches is not as great.

(3) After the data is arranged as in Figure 1 the next step in the procedure is factor analysis of the data matrix. The term factor analysis is somewhat ambiguous as it can refer to a number of different sequences of mathematical procedures. The procedure recommended here is the following.

(a) Compute the correlation matrix R of the data variables. This makes variation comparable across data variables of different scale as it incorporates standardization of all variables in the matrix. In addition R is a square symmetric matrix appropriate for use with widely available computer programs providing a principal component solution to the factor analysis problem.

(b) Compute the principal components[10] of the correlation matrix and rotate[11] the factors to a theoretically satisfactory solution. The solution gives the values of the "factor loadings". Factor loadings may be interpreted as correlations of data variables with a new set of variables which are linear combinations of the old. The new set of variables are the factors. The component model is expressed as:

$$\begin{aligned}
Z_1 &= \alpha_{11} F_1 + \alpha_{12} F_2 + \ldots \alpha_{1m} F_m \\
Z_2 &= \alpha_{21} F_1 + \alpha_{22} F_2 + \ldots \alpha_{2m} F_m \\
&\vdots \\
Z_n &= \alpha_{n1} F_1 + \alpha_{n2} F_2 + \ldots \alpha_{nm} F_m
\end{aligned}$$

Where the Z's are standardized data variables, the F's are the new variables (the factors) and the α's are the coefficients given by the principal components factor solution. More specifically, factor analysis programs yield the α's in the form of a "factor loading matrix". The pattern of loadings in the matrix may then be used to "interpret" or to "infer" the character of the F's in the above set of equations. Now, provided that a) the factors so interpreted meet the theoretical criteria of the researcher and b) that a representation of the data variables by the factors achieves sufficient economy relative to his standard, it is suggested that the researcher should consider the factors as defining the hypothetical state variables of the systems which are being studied.

(c) If this is done the state of each individual political system-time-slice (data case) will be described by the set of factor scores (or values of the factors for each case). The solution of (b) however, does not give the value of the factors (the factor scores) for each case. Rather as already indicated it yields the matrix of coefficients relating Z-values to F-values. The next step then, is computation of the F-values, or realizations of the state variables for the individual political system-time-slices.[12] Such a computation produces a matrix of state variable values and hence state-descriptions of political system-time-slices. Figure 2 illustrates such a matrix of factor scores. The columns define the factor score variables we suggest be considered state variables. The rows denoted

$$\begin{array}{c|ccccc|}
 & F_1 & F_2 & F_3 & F_4 & F_5 \\
\hline
A & a_1 & a_2 & a_3 & a_4 & a_5 \\
\hline
B & b_1 & b_2 & b_3 & b_4 & b_5 \\
\hline
\vdots & & & & & \\
\hline
K & k_1 & k_2 & k_3 & k_4 & k_5 \\
\hline
\end{array}$$

A,B . . . K = political systems time-slices

F_1 . . . F_5 = State Variables

a_1 . . . a_5 and b_1 . . . b_5 = values of the State Variables

Figure 2 - Factor Score Matrix Representation of System State

by capital letters A, B . . . K refer to political system-time-slices contributing the data variables which were factor analyzed. A state description of A, thus, is given by the values a_1, a_2, a_3, a_4 and a_5, and similarly one for B is given by b_1, b_2, b_3, b_4 and b_5.

A geometric interpretation of the above notions of state variable, and state description of a system-time-slice may also be helpful to the reader. The factors or state variables may be viewed as generating a vector space (or constituting the basis of a vector space) in which the row vectors or political system-time-slices may be located. The means of locating these time-slices is through their state descriptions. That is, the rows of numerical values or factor scores giving the values of the factors for each of the cases or systems also give the components of the case vectors. In Figure 3, a vector space with three basis functions, or factors, is delineated.

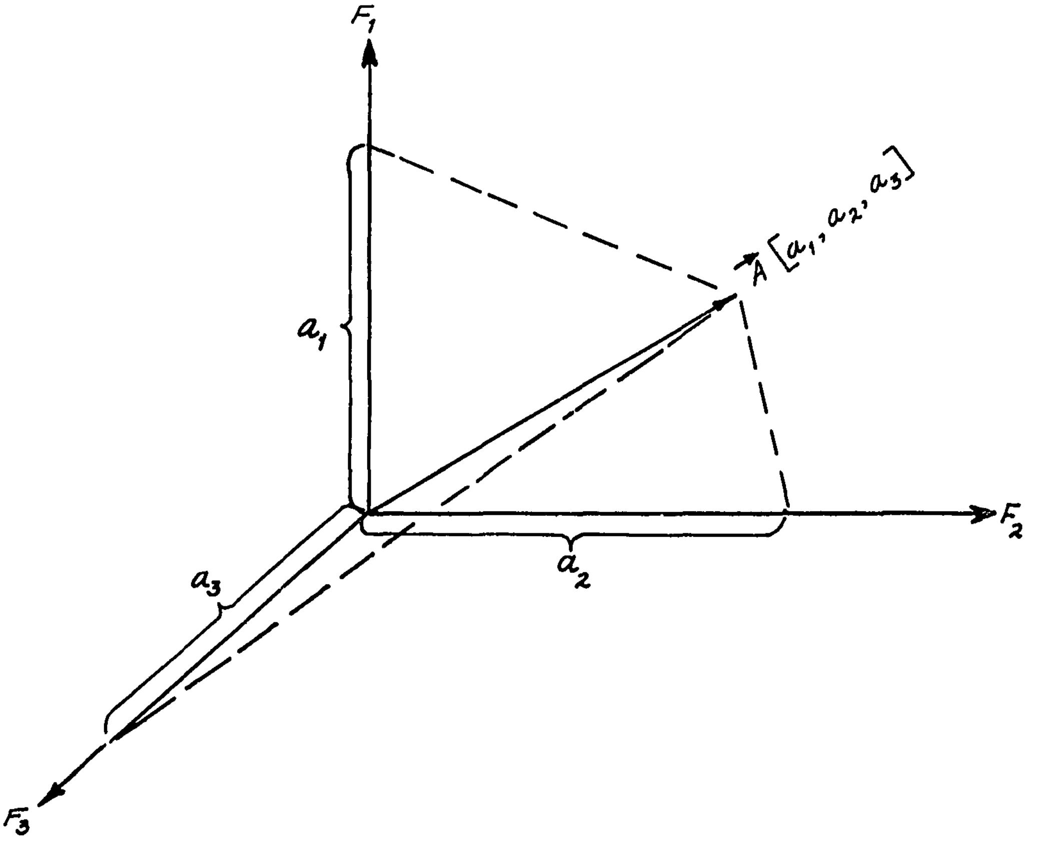

Figure 3 Geometric representation of state variables and state descriptions

System-time-slice A is represented in the figure as a vector whose components are a_1, a_2, and a_3. These components serve to locate the vector in the space. They are also the values of the state variables F_1, F_2, and F_3 for time-slice A. Thus, the state description of A expressed in algebraic terms is equivalent to its location in the vector space generated by F_1, F_2, and F_3.

Why do we suggest the above procedure as a potentially productive means of selection of fruitful state variables? Basically, there are three problems besetting the selection of political system state-variables which factor analysis either helps to solve, or to clarify.

The first such problem is that of defining state variables which are abstract rather than concrete in character. Earlier we distinguished two instances of relations between the observable phenomena systems analysis is supposed to account for, and state variables. First, the phenomena of interest may themselves be selected as state variables. Second, such phenomena may be connected through functional relations to state variables which are not directly observable. While the more direct strategy is to select the observable phenomena themselves as state variables, if this is done we are assuming that concrete characteristics such as GNP/capita, number of people killed in a nation in a single year, size of governmental budget, and so on are key theoretical concepts upon which we will build our theoretical edifice underlying systems analysis. The other alternative of connecting such phenomena as GNP/ capita to state variables through functional relations allows the use of abstract theoretical terms such as "power", "political culture", and "economic development", as key theoretical foci. Thus, if social scientists wish to make use of abstract terms such as those above in a theoretical capacity, and most of them seem to, it in turn is necessary to define state variables not as observable phenomena but rather in terms of the functional relations such phenomena bear to them. Factor analysis provides such a definition of state variables, as the factor model expresses data variables as functions of a set of mathematically derived abstract factors.

The second problem besetting the selection of political system state variables is that of theoretical economy. As systems analysis in science has attempted traditionally,we would like in describing political system behavior to employ state descriptions comprised of a few key state variables whose variations with time can in turn be described through the use of simple mathematically expressed laws which account for the significant behavior we wish to explain and/or predict. The state variables of political systems however must at the same time be representative of variation in hundreds of attribute phenomena we are interested in accounting for. It is thus necessary to express variation in hundreds of data variables in terms of a few underlying theoretical constructs. Factor analysis is one way of performing such data reduction, to the extent that such reduction is implicit in a data set. If, alternatively the variables within such a set are not linearly interdependent, and hence substantial data reduction through use of linear combinations of the data is impossible, then factor analysis will clarify this state of affairs for researchers, also.

Another aspect of theoretical economy in systems analysis is the requirement of functional independence of state variables at given points in time mentioned above. Factor analysis applied in the manner recommended insures that the hypothetical state variables used in systems analysis are both linearly independent of each other and uncorrelated. This does not exclude the possibility, of course, that other non-linear functional relations do not exist among state variables, but it does exclude one important source of redundancy besetting their selection.

The third problem besetting selection of state variables is that of measurement validation. Suppose "amount of national power" is selected as a hypothetical state variable of political systems and some indicator, for example, number of military personnel, is designated as an attribute measuring amount of power. Suppose further a mathematical relation is formulated expressing amount of national power as a function of military personnel. The only way to validate such an attempt at measurement is to select another attribute measuring amount of power, formulate a second equation relating amount of power to it, and compare the consistency of the two hypothesized measures. In general when a procedure such as the above has been followed by political scientists a high level of consistency between candidate measures of abstract variables has not been found. Rather such a procedure normally results in the discovery of moderate to low correlations between the two hypothesized measures. This means that neither attribute is convincingly validated as providing a measurement of the hypothesized state variable and moreover a decision procedure is not available for choosing between the candidate measures, or for weighting them in some manner that will allow derivation of state variable values.

Factor analysis alleviates the measurement problem. Specifically, a rotated factor solution can delineate patterns of intercorrelations among a large number of potential indicator variables. If factors are interpreted as state variables then this in effect means that the state variables lie at the center of, and moreover are expressions of, the pattern of intercorrelated hypothetical measures. Whatever consistency among measures exists, is embodied in the factor constructs. Moreover all candidate measures contribute to the value of the state variable or factor according to their degree of participation in the pattern of intercorrelations. The weight to be accorded each variable in determining state variable values for the cases is determined by the empirical pattern of intercorrelations which is taken into account through a decision procedure contained in the Factor Model.

It must be emphasized that the preceding is not meant to imply that factor analysis solves the measurement validation problem with regard to state variables, for factor analytic state variables may still not provide fruitful components of laws of system transition. However, given the situation that hypothesized measures of state variables are generally not perfectly correlated, some decision procedure is needed for the derivation of state variable values from data values which on theoretical grounds provide equally sound but less than perfectly consistent measures of these state variable values. Factor analysis provides such a procedure.

A concluding word: some political scientists question the use of factor analysis because they believe the technique assumes a linear model of relations between state variables and indicators. While particular factor analyses may indeed assume such relations this is not a general or necessary characteristic of factor analysis. Referring again to the example cited above, if it is assumed that the relation between the indicator number of military personnel, and the hypothetical state variable amount of national power is expressed by:

$$x = a(\sqrt{\cos y_1})$$

where x is amount of power and y_1 is number of military personnel; and other non-linear relations between amount of national power, x, and a set of other indicators y_2, y_3 ..., y_n have also been hypothesized, then the problem of measurement validation detailed above still may arise. Moreover factor analysis of the various values of x resulting from the alternative measurement hypotheses will still provide a means of alleviating the problem of consistency.

c. Derivation of Laws of System Transition

A third guideline for quantitative systems analysis refers to the problem of deriving laws of system transition. If the state variables previously defined with the help of factor analysis are represented by F_1, F_2, F_3, and F_4 then a set of functions for time series[13] analysis must be found such that:

$$F_1^{t} = f_1\,(F_1^{t}o,\ F_2^{t}o,\ F_3^{t}o,\ F_4^{t}o,\ t - t_o)$$

$$F_2^{t} = f_2\,(F_1^{t}o,\ F_2^{t}o,\ F_3^{t}o,\ F_4^{t}o,\ t - t_o)$$

$$F_3^{t} = f_3\,(F_1^{t}o,\ F_2^{t}o,\ F_3^{t}o,\ F_4^{t}o,\ t - t_o)$$

$$F_4^{t} = f_4\,(F_1^{t}o,\ F_2^{t}o,\ F_3^{t}o,\ F_4^{t}o,\ t - t_o)$$

There are, of course numerous possibilities specifiable in connection with the appropriate form of the functions f_1, f_2, f_3, and f_4. We will not attempt to speculate on the relative merits of any of these here.[14] Rather, we merely indicate that whatever form these functions take they can be evaluated through use of a linear model.[15] Assume for instance that in "actuality"

$$F_1^{t} = .356\ F_1^{t}o\ F_2^{t}o\ F_2^{t}o\ F_3^{t}o\ F_4^{t}o\ [\mathrm{Sin}\ (t - t_o)].$$

Then given an appropriate linear model in the variable $G_1 = \mathrm{Sin}\ (t - t_o)$

$$F_1^{t} = \alpha_{11}\, G_1\ .$$

If alternatively

$$F_1^{t} = .356\ F_1^{t}o\ F_2^{t}o\ F_3^{t}o\ F_4^{t}o\ [\mathrm{Sin}\ (t - t_o)].$$

$$+\ .623\ F_1^{t}o\ F_2^{t}o\ F_3^{t}o\ F_4^{t}o\ [\mathrm{Cos}\ (t - t_o)]\ ,$$

then again given an appropriate linear model in the variables $G_1 = \text{Sin}\ (t-t_o)$ and $G_2 = \text{Cos}\ (t-t_o)$

$$F_1^t = \alpha_{11} G_1 + \alpha_{12} G_2.$$

What the above suggests is that insofar as our hypothetical generalizations about time series incorporate assumptions of linearity one can test those assumptions by employing linear vector space analysis, that is to say factor analysis, on a time-series data matrix.[16] The third suggested guideline for research on political systems analysis then, is that factor analysis be utilized for checking the linearity assumptions implied in time-transition hypotheses. We will now describe how this may be accomplished.

Assuming a single case i with state variables F_1, F_2, F_3 and F_4 having values at each of 10 time points, inspection of the variation of F_1 with changing F_2, F_3, F_4 and t yields the hypothesis

$$F_1^t = F_1^{t}o + F_2^{t}o\ F_3^{t}o\ F_4^{t}o\ (t - t_o) + 16(t - t_o)^2$$

This hypothesis can be checked through factor analysis of a matrix such as that in Figure 4.

According to the hypothesis a linear combination of three terms is needed to account for F_1^t. If the factor model is applied to a data matrix such as that in Figure 4 a series of linear simultaneous equations is derived of the form

$$\begin{aligned}
F_1^t &= \alpha_{11} G_1 + \alpha_{12} G_2 + \ldots + \alpha_{1m} G_m \\
F_2^t &= \alpha_{21} G_1 + \alpha_{22} G_2 + \ldots \quad \alpha_{2m} G_m \\
F_3^t &= \alpha_{31} G_1 + \alpha_{32} G_2 + \ldots \quad \alpha_{3m} G_m \\
F_4^t &= \alpha_{41} G_1 + \alpha_{42} G_2 + \ldots \quad \alpha_{4m} G_m \\
(t-t_o) &= \alpha_{51} G_1 + \alpha_{52} G_2 + \ldots \quad \alpha_{5m} G_m \\
(t-t_o)^2 &= \alpha_{61} G_1 + \alpha_{62} G_2 + \ldots \quad \alpha_{6m} G_m \\
1 &= \alpha_{71} G_1 + \alpha_{72} G_2 + \ldots \quad \alpha_{7m} G_m
\end{aligned}$$

Factor score (state variable) and hypothetical time function values

Time points	F_1	F_2	F_3	F_4	$(t-t_o)$	$(t-t_o)^2$	(1)
1955							
1956							
1957							
1957							
1958							
1959							
1960							
1961							
1962							
1963							
1964							

Figure 4 Time Series Matrix of State Variables and Time Function Values for a Single Case i

Assuming appropriate rotation of the factor solution, at least 3 factors (G's) must emerge from the analysis, such that one of these is highly correlated with $(t-t_o)$, another is highly correlated with $(t-t_o)^2$, and a third is highly correlated with 1. The linear combination of these three factors must account for most of the variation in F_1^t. Thus, the α-coefficients accompanying these three factors in the linear equation relating F_1^t to $G_1 \ldots\ldots G_m$, must be relatively high. α- coefficients (in this equation) accompanying factors other than the three referred to, must on the other hand closely approach zero. Any other result of the hypothetical factor analysis is inconsistent with the linear form assumptions implicit in the original non-linear hypothesis.

In viewing an application of factor analysis such as that delineated above it should be emphasized that the procedure utilized is similar to that in conventional cross-sectional factor analysis and that the mechanics of interpretation of results also differ little. Thus, the variables F_1, F_2, F_3, F_4, $(t-t_o$

and $(t-t_0)^2$ and the constant (1), are intercorrelated prior to computation of the principal components of the correlation matrix. The factor analysis clarifies the structure of intercorrelations among the variables relative to system-time-slices. The factors designated $G_1, \ldots, G_m$ in the above illustration are interpreted through examination of a matrix of α-coefficients or factor loadings. The difference between cross-sectional or R-factor analysis and the type just illustrated (called P-factor analysis by Cattell) lies in the fact that system-time-slices are all derived from a single case i, and therefore the factor analysis extracts the patterns of intercorrelation of the variables only as the values of the variables change with changes in time. In cross-sectional factor analysis, in contrast, system-time-slices are derived from many cases but from a single time period. Thus cross-sectional factor analysis extracts the patterns of intercorrelation of the variables only as the values of the variables change with changes in case.

In sum, linear functional forms implied by over-time hypotheses can be tested for a single case i, through factor analysis of a time-series data matrix of the type illustrated in Figure 4. This method of factor analysis has seen relatively infrequent use but the rationale behind its application has been quite well worked out by Cattell (1966a). If factor analysis can help in checking out the linear form assumptions implied by over-time hypotheses about single cases, it is relevant to ask whether such assumptions implied by over-time hypotheses intended to encompass many cases can similarly be tested. The answer is yes, and the method to be used[17] is a relatively straightforward extension of that already outlined for the single case.

We begin by referring again to a matrix of the type considered in Figure 1. This matrix contained political system-time-slices of both a cross-sectional and longitudinal character. Factor analysis of the matrix as indicated above produces state variables generalizable to all system-time-slices and representative of variation in all such time-slices. One product of factor analysis for the purpose of deriving state variables is a matrix of factor scores as represented in Figure 2. Such a matrix may be employed as the starting point for an extension of P-factor analysis of change in state variable values to multiple cases.

The steps in such a multiple case P-factor analysis are as follows.

(1) Organize the factor scores of the system-time-slices matrix resulting from the state variable derivation process so that the time-slices for each political system case are arranged sequentially.

(2) Add values of functions derived from the over-time hypotheses being tested. The matrix resulting from these two steps will resemble Figure 4 but will be an expanded version of it. That is to say the new matrix is a multiple-case, time-series matrix of state variables and hypothesized time function values.

(3) Next, standardize the factor score values for the sequentially arranged system-time-slices of each case to be analyzed separately. This standardization removes variance associated with differences in means and standard deviations between factor score distributions of each case. Such a transformation is essential because our object in testing the linear form assumptions implied in over-time hypotheses applying to multiple cases is to generalize over many cases about within case variation with changing time. In order for the analysis to identify general patterns of within case variation with changing time, the magnitude of variation which is specific to each case, that is to say, which is associated with the specific means and standard deviations of the time-series factor score distributions of each case must be removed from the matrix. This the suggested standardization will accomplish.

A representation of a case separate standardized multiple-case time-series matrix resulting from steps 1-3 is presented in Figure 5. Here the rows are systems time-slices, and the columns are state variables and state variable predictions derived from overtime hypothesis. Thus, Z, . . . Z_k are state variables, Z_{k+1} ... Z_n are state variable predictions derived from hypothetical time functions. The double lines denote both case and standardization partitions. Thus, cells Z_1, U.K. 1935-55 represent a standardized distribution of Z_1 state variable values for the U.K. system covering the period 1935-1955, cells Z_1, S.U. 1935-55 represent a standardized distribution of Z_1 state variable values for the S.U. system for the same period and so on.

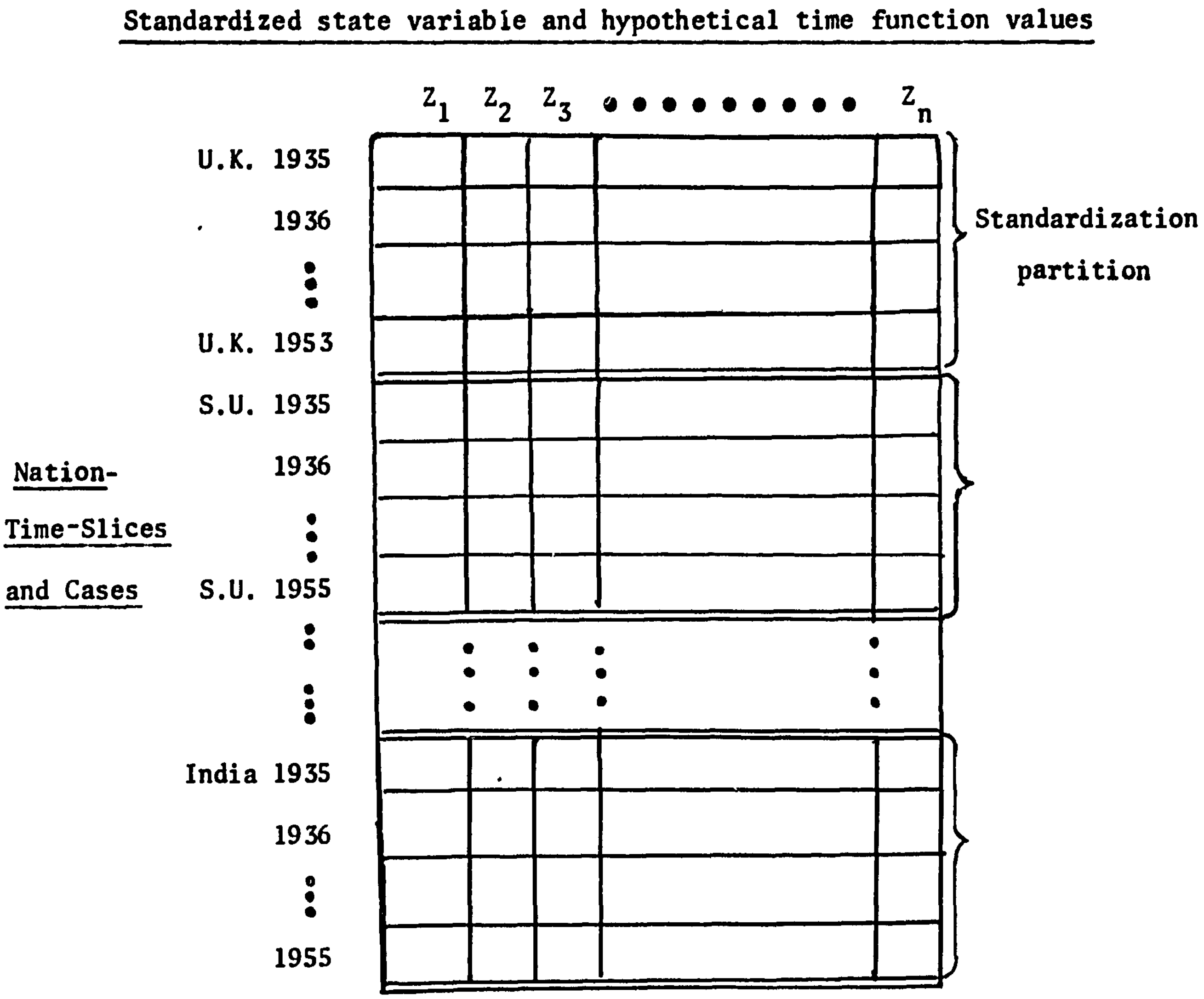
Standardized state variable and hypothetical time function values
Z1 Z2 Z3 Zn
U.K. 1935
1936
U.K. 1953
S.U. 1935
1936
S.U. 1955
India 1935
1936
1955
Nation-Time-Slices and Cases
Standardization partition

Figure 5 Representation of a Case-Separate Standardized Multiple-Case Time-Series Matrix

(4) After the state variable values are arranged and transformed as in Figure 5, the correlation matrix of the resulting transformed factor score matrix should be computed. A correlation between Z_1 and Z_2 in this context may be interpreted as the extent to which changes in Z_1 and Z_2 are correlated relative to changes in time period for all cases in the time-series matrix.

(5) Thus, if the matrix of intercorrelations of step 4 is factor analyzed utilizing principal components, and rotation, the result will be the delineation of patterns of intercorrelation of state variable values and hypothetical time function values common to all cases analyzed. More specifically if the variation in state variable values is highly intercorrelated over time and variation in hypothetical time function values is highly loaded on the same state variable factors then the analyst has hit on fruitful hypotheses of time-variation. An illustrative (though highly idealized) factor loading matrix is presented in Figure 6 in order to help clarify this point.

		Orthogonally Rotated Factors		
State variables and Time functions		1	2	h^2
1	F_1	.85	.53	.98
2	F_2	.10	.98	.96
3	F_3	.70	.71	.99
4	F_4	.97	.20	.98
5	$(t-t_0)^2$	.99	.10	.99
6	$\cos(t-t_0)$	.10	.98	.97
% total variance		52.6	45.9	98.5
Eigenvalues		3.15	2.76	

Figure 6 Illustration of Orthogonally Rotated Factor Loading Matrix of State Variables and Time Functions

In the above example $(t-t_0)^2$ and $\cos(t-t_0)$ are the two linear terms in the over-time hypothesis at issue. A factor analysis of the type described above has yielded two factors delineating patterns of intercorrelated variation accompanying time change in the state variables F_1 to F_4. The factor loading matrix indicates that each of these factors is interpretable as one of the two functional forms in the over-time hypothesis. Expressed in algebraic terms the factor analysis has confirmed the following hypotheses relating F_1, F_2, F_3, and F_4 to the terms containing time as a variable.

$$F_1 = .85\ (t-t_o)^2 + .53 \cos(t-t_o)$$

$$F_2 = .10\ (t-t_o)^2 + .98 \cos(t-t_o)$$

$$F_3 = .70\ (t-t_o)^2 + .71 \cos(t-t_o)$$

$$F_4 = .97\ (t-t_o)^2 + .20 \cos(t-t_o)$$

d. Summary

The strategy for quantitative political systems analysis outlined above is, as already indicated, not a "magic formula" for solution of the problems presented by political systems analysis. Rather it is merely a set of guidelines for aiding researchers. Major aspects of the strategy may be briefly summarized as follows.

(1) If possible political systems should be viewed as one-component entities with a variety of properties. This allows system-time-slices to be represented as rows of a data matrix, and thereby greatly simplifies the task of quantitative systems analysis.

(2) State variable derivation may be greatly aided through factor analysis of a data matrix of political system-time-slices provided that the matrix is "representative" of the universe of system-time-slices which is the object of generalization. Possible results of the factor analysis of such a matrix are: a) the discovery of generalizations about system-time-slices relating values of data variables characteristic of time-slices to values of state

variables also characteristic of them; and b) computation of state descriptions of system-time-slices represented in the original data matrix. Specific problems relating to state variable derivation, which are alleviated or clarified through use of the factor model, are: a) The problem of specifying abstract state variables in terms of concrete data; b) The problem of theoretical economy in relation to both its data reduction and functional independence of state variables aspects; and c) The problem of measurement validation (in the sense of indicator consistency).

(3) The discovery of laws of time-transition applicable to political systems may be aided through checking of the linear form assumptions present in over-time hypotheses. In instances, where such hypotheses have been formulated for single cases, they may be tested through factor analysis of a single case time-series matrix whose columns are state variable and hypothetical time function values and whose rows are sequentially arranged time-slices of the single case. In instances where time-transition hypotheses having applicability to multiple cases have been formulated, it is possible to test these through factor analysis of a case separate standardized multiple-case time-series matrix. The columns of such a matrix are state variable and hypothetical time function values. The rows are system-time-slices arranged by case and sequentially within case blocks or partitions. Standardization of the column distributions of the matrix is performed separately within case partitions. This is a necessary step if the factor analysis is to test multiple-case hypotheses about over-time variation.

In conclusion, the strategy for quantitative systems analysis presented, is a series of recommendations for dealing with problems arising in the three major stages of quantitative systems analysis, selection of system components, selection of state variables, and derivation of laws of system transition. It should be emphasized that the strategy has not been, and cannot be, justified relative to the fruitful theories its use guarantees researchers will find. The discovery of such theories cannot be guaranteed by procedures such as that outlined, but only by scientific genius. What the strategy can accomplish is aid for the researcher in handling specific problems mentioned above relating to quantitative systems analysis. At the risk of being repetitious these problems once again are:

a) The number of system components to be considered
b) The specification of abstract state variables in terms of concrete data
c) Theoretical economy
d) Measurement validation
e) Confirmation of linear form assumptions in system-transition laws.

State Variable and Time-Transition Analysis of Domestic Conflict: An Illustration

a. Introduction and Data Base

It is always helpful in presenting a new quantitative methodology to include a concrete application. The remainder of this paper is largely concerned with such an application.

More specifically, the major purpose of this section is to illustrate "how one might go about" applying the systems methodology outlined and recommended above.

Since the analysis to be performed is concerned with real data, however, questions of both the methodological and substantive significance of the analysis will arise. Methodological questions are not always neatly separable from substantive ones, but in the ensuing discussion an attempt will be made to distinguish the two types of questions. More specifically, in highlighting methodological questions the results to be presented will be related to the problems besetting state variable and system-transition analysis distinguished above, while in highlighting substantive questions the usual method of relating results to explicitly stated hypotheses will be employed.

Table 1 Data Base for Domestic Conflict Analysis

Principal Author of Data Source	Time Periods Gathered by Source	Nations	Variables
1. Rummel (1963)	1955, 1956, 1957	Afghanistan, Albania, Argentina, Australia, Belgium, Bolivia, Brazil, Bulgaria, Burma, Cambodia, Canada, Ceylon, Chile, China, (People's Rep.) China, (Rep. of), Columbia, Costa Rica, Cuba, Czechoslovakia, Denmark, Dominican Rep., Ecuador, El Salvador, Ethiopia, Finland France, Germany (Dem. Rep.), Germany (Fed. Rep.), Greece, Guatemala, Haiti, Honduras, Hungary, India, Indonesia, Iran, Iraq, Irish Rep., Israel, Italy, Japan, Jordan, Korea (Dem. Rep.), Korea (Rep. of), Lebanon, Liberia, Mexico, Nepal, Netherlands, New Zealand, Nicaragua, Norway, Outer Mongolia, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Rumania, Saudi Arabia, Spain, Sweden, Switzerland, Thailand, Turkey, Union of S. Afr, U.S.S.R., United Kingdom, United States, United Arab Rep., Venezuela, Yugoslavia	**1. Assassinations** **2. General strikes** **3. Guerrilla wars** **4. Major Gov't crises** **5. Purges** **6. Riots** **7. Demonstrations** **8. Revolutions** **9. No. killed in domestic violence**
2. Tanter (1964)	1958-60		
3. Rummel (1965)	1962-1963 1963-1964		
4. Borock (1967)	1964, 1965, 1966		

The data base utilized for the analysis comprises domestic conflict data gathered for 9 variables over 74 nations and 9 time periods. This is a total of 666 time-slices. The following table lists the variables, nations, time periods, and data sources involved. Readers examining Rummel (1965) will note that the variables accompanying that study do not entirely correspond to the list of variables given in Table 1. This is due to the fact that Professor Rummel revised and expanded the coding scheme initially used in his 1963 study for purposes of the 1965 study. It was possible however to generate data for the same list of variables as was employed in the earlier study by collapsing data categories of the 1965 study. More specifically, four categories of the 1963 study were revised for the 1965 study. These categories and their 1965 equivalents are presented in Table 2.

Table 2 Rummel (1963) Data Categories Revised in Rummel (1965) and Their Equivalents

1963 Category	1965 Equivalents
Guerilla war	Large-scale terrorism + small-scale terrorism + large-scale guerilla war + small-scale guerilla war
Riots	Riots + 2 (Rioting)
Demonstrations	Demonstrations + 2 (demonstrating)
Revolutions	Coups + Revolts + Civil Wars + Mutinies

Interested readers will find the data used for the analysis reproduced in Appendix A of this paper. Details involved in initial data collection may be found in the sources cited in Table 1.

b. Method and Hypothesis

The method used in the concrete analysis of domestic conflict has been outlined at length above. Our substantive purposes in this instance were a) to arrive at generalizations about the relation of the nine data variables to a smaller set of state variables, where the generalizations apply to nation-system-time-slices, and b) to test hypotheses about system-transition over-time with regard to changes in the state variable values comprising nation system-time-slices.

To reach the first objective, it was assumed, as recommended earlier, that the political systems of interest, in this instance nation-states, may be viewed as one-component systems. The data base described above was then arranged in a manner appropriate for factor analysis of individual political system-time-slices, also as recommended earlier. Thus, the data base was arranged in a matrix of 666 rows by 9 columns. The form of the matrix was similar to that illustrated in Figure 1 above. System-time-slices were arranged sequentially for each nation, and the sequentially arranged sets of time-slices of all nations were then placed in the same matrix. This matrix was then transformed into a correlation matrix (the 9 variables were intercorrelated) and factor analyzed. After an appropriate rotation, factor scores were derived as recommended above.

In order to test system-transition hypotheses the factor scores resulting from the state variable analysis were placed in a matrix of the same form as Figure 5 above. As in Figure 5, each of the nation-sets of system-time-slices was separately standardized. The matrix was then factor analyzed.

A word is necessary on the hypotheses guiding both state variable and system-transition analyses. In neither case were specific hypotheses formulated about the precise form of the mathematical equations resulting from the factor analysis. Regarding the state variable analysis however, it was expected that the results of Rummel (1963, 1965) Tanter (1964), Borock (1967) and others would be replicated and that either three factors called turmoil, subversion, and revolution would emerge from the analysis or alternatively two factors called turmoil and internal war (as found by Tanter) would emerge. Regarding the system-transition analysis only the most general hunches governed the analysis. To wit: it was felt that the functions describing system-transition with change in time would most probably be non-linear. In fact given the great emphasis in social theory on cyclic phenomena it was suspected that "sine time" would enter prominently into the time-transition equations. Since a tight deductive justification for this suspicion was not developed however, and since so little knowledge of multivariate domestic conflict time series is presently available, it was felt that discretion dictated inclusion of a number of time-transition functions in the time series matrix. These were t, log t, $\sqrt{t}$, and sin t. The following values of t were given to each of the time periods designated in Table 1: 1955 = 1; 1956 = 2; 1957 = 3; 1958-60 = 5; 1962-63 = 8; 1963-64 = 9; 1964 = 10; 1965 = 11; 1966 = 12. It should also be noted in this context that the period of sin t is 2π, or 6.28 years, so that approximately 2 cycles are encompassed by the values 1 to 12, specified for the annual time periods.

The hypothesis that sin t would enter prominently into the time-transition equations can be expressed more precisely than above. Thus, it was suspected that a single factor would account for most of the within-nation variation in factor scores due to changes in time period. More specifically, planned violence, unorganized violence, and number killed in domestic violence (the state variables) were all expected to be highly loaded on a single factor along with sin t.

c. Results and interpretation of the state variable analysis

1. Substantive Interpretation of the Results

The product moment correlation matrix computed from the original 666 x 9 data matrix (included in Appendix A) and the factor matrices derived from the correlation matrix are reproduced in Tables 3 and 4.

As indicated in Table 4 only the first three factors were rotated and interpreted. This was done a) because the eigenvalue accompanying the fourth factor was less than 1.0 and b) no sharp break in the distribution of eigenvalues less than 1.0 provided a justification for rotating one or more of the factors accompanying these eigenvalues. Given the above fact and the relatively small amount of total variance accounted for by the factor analysis

(55.3 %) it appears that most of the data variables analyzed are not highly interdependent vis-a-vis system-time-slices. Thus, among the 9 variables, only riots, demonstrations, and number of people killed in domestic violence, have more than 50% of their variance accounted for by the linear model employed. Particularly glaring is the low communality of the guerilla war variable (.22) in the factor analysis.

Table 3 Correlation Matrix of 9 Domestic Conflict Variables for 666 Nation-Time-Slices

Variables	1	2	3	4	5	6	7	8	9
1. Assassinations	1.00								
2. General strikes	.24	1.00							
3. Guerilla wars	.16	.06	1.00						
4. Major Government crises	.25	.24	.23	1.00					
5. Purges	.20	.21	.19	.25	1.00				
6. Riots	.23	.26	.12	.14	.14	1.00			
7. Demonstrations	.03	.02	.03	.01	.01	.60	1.00		
8. Revolutions	.20	.28	.24	.34	.40	.14	-.01	1.00	
9. No. killed in domestic violence	.01	.01	.04	.13	.21	.10	.07	.16	1.00

Against these negative aspects of the factor analytic results two points supporting the substantive validity of the analysis may be made. First, the 55.3% of total variance accounted for is consistent with previous analyses of domestic conflict. More specifically, while Rummel's 1955-57 conflict analysis (see Rummel, 1963) accounted for 70.8% of the total variance in the data variables, his 1962-63 and 1963-64 (see Rummel 1965) annual system-time-slice analysis accounted for only 48.6% and 45.1% of the variance present in those respective data sets. Second, and far more significant, the results above are similar in their theoretical implications to previous factor analyses of domestic conflict data on smaller samples of time-slices.

In a recent comparative analysis of domestic conflict studies Rummel (1965) points out that among the three dimensions of domestic conflict originally identified by him called turmoil, revolution, and subversion, the

Table 4 Factor Loading* Matrices of Domestic Conflict Variables for Time-Slices

	Unrotated factors[a]				Orthogonally Rotated Factors[b]		
Variables	1	2	3	h^2	1 (planned violence)	2 (unorganized violence)	3 (number killed)
1. Assassinations	(.53)	-.04	-.43	.47	(.56)	.17	-.35
2. General strikes	(.54)	-.03	-.39	.45	(.57)	.18	-.31
3. Guerilla wars	.44	-.16	-.03	.22	.46	.03	.05
4. Major Govt. crises	(.61)	-.25	-.04	.43	(.65)	.01	.06
5. Purges	(.61)	-.26	.27	.51	(.61)	.01	.37
6. Riots	(.55)	(.72)	-.04	.82	.23	(.88)	.02
7. Demonstrations	.28	(.85)	.12	.81	-.10	(.89)	.09
8. Revolutions	(.67)	-.32	.10	.55	(.71)	-.02	.22
9. No. killed in domestic violence	.30	-.02	(.80)	.73	.15	.11	(.83)
Percent total variance	26.8	16.5	12.0	55.3	24.8	18.2	12.3
Percent common variance	48.4	29.9	21.6		44.8	32.9	22.2
Eigenvalues	2.41	1.49	1.08				
Sum of squares					2.24	1.64	1.10

---

* Loadings ≥ |.50| are given in parentheses

[a] Principal Axis method with unities in principal diagonal of correlation matrix

[b] Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

> "turmoil dimension has high stability from study-to-study i.e., from behavior subspace to behavior subspace ... Revolution also has fair stability across the conflict subspace with three studies, in addition to the 1955-57 data, yielding a similar dimension ... subversion is the weakest dimension, with only one additional study delineating it as a pure factor. Yet the factor exists without loss from study-to-study either in a fused state or separated onto turmoil or revolution."

This interpretation is in the main confirmed by the present analysis. More specifically, Table 4 indicates an unorganized violence dimension similar to Rummel's turmoil dimension in that its two marker variables, riots and demonstrations, are the same. The revolution dimension which appeared in other studies also appears in this one as a planned violence factor. Subversion, Rummel's weakest dimension does not emerge in the above analysis, but rather is fused with the planned violence factor. Thus, in Table 4 assassinations and guerilla wars are positively correlated with planned violence. The correlations referred to are of only moderate strength however.

A dimension defined almost wholly by the variable number killed in domestic violence is the third factor to emerge from the present analysis. This factor has not appeared in previous domestic conflict factor analyses. Its occurrence here may be a consequence of the larger sample of system-time-slices in the data base and may indicate that in general, planned and spontaneous violence are equally destructive of human life, and therefore the aggregate occurrence of number killed in domestic violence is uncorrelated with the other 2 factors.

The above analysis also confirms a second interpretation by Rummel (1966) of previous domestic conflict factor analyses. This interpretation views previous studies as essentially demarcating dimensions of spontaneous (turmoil) and planned (revolution and subversion) conflict. The confirmation of this interpretation provided by Table 4 is, it is felt, a strong one as a) the sample of time-slices included in this study is much more extensive than those of previous analyses and b) the planned violence factor loads all planned violence variables (assassinations, general strikes, purges, and revolutions) but one (guerilla warfare) above the .50 level.

In sum, the linear model employed here to express static relationships between 9 domestic conflict data variables and 3 hypothetical state variables makes some theoretical sense, and therefore may be said to merit an attempt at validation through an analysis of the time-transition patterns of system time-slice states. However, it must be emphasized that the model is not outstandingly successful in the amount of total time-slice variance (55.3%) for which it accounts. While it is beyond the scope of the present paper to attempt revisions of the model, future research should attempt such revisions through study of the effects of employing more complicated functions of the data variables in the linear model.

2. Methodological Interpretation of the Results

It was indicated earlier that factor analysis may aid the selection of state variables through the solution or clarification of three problems arising in connection with the process of state variable selection. The three problems are the specification of abstract state variables in terms of concrete data, theoretical economy, and measurement validation. The results just reported illustrate well the contributions factor analysis can make to solution of these problems.

With respect to specification of abstract state variables it is sufficient to note that the three constructs, planned violence, unorganized violence and number killed in domestic violence are specified in terms of the data variables by the set of linear simultaneous equations implicit in the orthogonally rotated factor loading matrix of Table 4. More specifically, each row of factor loadings gives the coefficients of a linear equation relating each of the data variables to the three constructs. The nine rows give the coefficients of nine simultaneous equations relating all data variables to the factor constructs and defining these factors as linear combinations of the data variables. Thus, application of the factor model has provided an unambiguous empirical specification of the three hypothetical state variables.

The second problem of theoretical economy is highlighted by the above results in the following manner. The linear independence and lack of correlation obtaining among the three factors insures that the state variables are the minimal number sufficient to account for 55.3% of variation in the data variables given a model linear in the data variables. With respect to the issue of data reduction moreover,the results indicate the extent to which the linear model used is successful in achieving such reduction. Again, the 55.3% of variation accounted for by a three factor theory relating to the nine data variables is not an entirely satisfactory result from the data reduction standpoint. Nevertheless, the factor analysis has clarified the problem of theoretical economy relative to the data, and it thus highlights the need for non-linear transformations of the data variables in future attempts to derive more adequate hypothetical state variables.

Finally, with respect to the third problem of measurement validation the results indicate that high levels of indicator consistency are not, in general, observable. Thus, the factor loadings of variables on the planned violence factor are only of moderate strength, though they do allow interpretation of this factor. The situation with respect to unorganized violence is somewhat better though the factor loadings of riots and demonstrations are still not high enough to allow unambiguous estimation of the factor. Lastly, the issue of consistency does not arise with respect to number killed in domestic violence as this indicator defines a specific factor.

d. Initial results and interpretation of the over-time analysis

1. Results

The product-moment correlation matrix computed for the 666 x 7 standardized factor score (system-time-slice state description) and hypothetical time function matrix, and the factor matrices derived from this correlation matrix are reproduced in Tables 5, 6, and 7. We have chosen to exhibit the unrotated and rotated factor matrices separately in this instance as the latter did not, due to an error by ourselves in analysis procedure include factor 4; the factor most closely correlated with planned violence.

Table 5

Correlation Matrix of 3 Domestic Conflict Standardized Factor Score Variables, and 4 Time-Function Variables for 666 Time-Slices (Factor Scores Were Separately Standardized for Each Nation-Set of Sequentially Arranged Time-Slices

	Variables	1	2	3	4	5	6	7
1.	Planned violence	1.00						
2.	Unorganized violence	-.14	1.00					
3.	No. killed in domestic violence	.03	-.39	1.00				
4.	Time	-.02	.02	-.03	1.00			
5.	Log time	.10	.04	.09	.24	1.00		
6.	$\sqrt{\text{time}}$	09	.02	.11	.16	.99	1.00	
7.	Sin time	.14	.02	-.13	.29	-.32	-.36	1.00

Table 6

Unrotated Factor Loading* Matrix of Three Domestic Conflict Standardized Factor Score Variables and Four Time Function Variables for 666 Time Slices (Time-Transition Analysis)

Variables	Unrotated Factors[a]							
	1	2	3	4	5	6	7	h^2
1. Planned Violence	.21	.29	-.07	(.91)	17	-.07	.00	1.00
2. Unorganized Violence	-.06	(-.72)	-.45	-.04	(.52)	-.04	.00	1.00
3. No. Killed in Domestic Violence	.23	(.68)	.36	-.31	(.50)	-.07	-.00	1.00
4. Time	.17	-.46	(.74)	.15	.10	.43	.01	1.00
5. Log Time	(.96)	-.21	.07	-.04	-.07	-.15	-.07	1.00
6. $\sqrt{\text{time}}$	(.96)	-.16	.02	-.07	-.08	-.18	-.07	1.00
7. Sin time	(-.53)	-.33	(.58)	.09	-.01	(-.51)	.00	1.00
Percent total variance	32.2	20.8	17.6	13.8	8.2	7.3	0.1	100.0
Eigenvalues	2.25	1.46	1.23	.97	.58	.51	.01	

*Loadings ≥ |.50| are given in parentheses

[a] Principal Axis method with unities in principal diagonal of correlation matrix

Table 7

Rotated Factor Loading* Matrix for Time-Transition Analysis

	Rotated Factors[a]			
Variables	1	2	3	h^2
1. Planned Violence	.13	.25	-.24	.14
2. Unorganized Violence	.09	(-.85)	-.02	.73
3. No. Killed in Domestic Violence	.08	(.80)	-.06	.64
4. Time	.32	.02	(.83)	.79
5. Log Time	(.98)	.03	-.00	.97
6. $\sqrt{\text{Time}}$	(.97)	.04	-.07	.95
7. Sin time	-.40	-.07	(.75)	.73
Per cent total variance	31.5	20.3	18.8	70.6
Per cent common variance	44.6	28.8	26.6	
Eigenvalues	2.21	1.42	1.31	

*Loadings $\geq |.50|$ are given in parentheses

[a] Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

The unrotated factor matrix of Table 6 indicates that variation in the hypothetical time functions is not highly related to time variation in the values of the three state variables. This is clearly shown in the case of Factor 4 upon which planned violence is highly loaded but no other state variable or time function. Factor 2 indicates that unorganized violence and number killed in domestic violence are negatively related in their time variation. Factor 2 also hints that the simplest time function, variation in time itself, may describe this over-time interdependency of the two state variables. However examination of Table 7, the rotated factor loading matrix, shows that this is not so. Here the over-time interdependency of unorganized violence and number killed in domestic violence is even more clearly defined by an orthogonal simple structure factor (#2). However, the effect of clearer delineation of the relationship has been to remove any appreciable relationship with any of the four time functions. In sum, the following are the primary results of the time-transition analysis requiring substantive or methodological interpretation.

(1) Planned violence has no discernible over-time linear dependency with any of the other state variables or time functions (including sin t).

(2) Over-time variation in unorganized violence and number killed in domestic violence are negatively related. None of the hypothetical time functions included in the analysis however, successfully describes the pattern of the relationship.

(3) A corollary of (1) and (2) is that none of the hypothetical time functions describe overtime variation in any of the three state variables.

2. Substantive Interpretation of Results

That planned violence has no discernible over-time dependency with the other two state variables suggests that planned violence may not be a "state variable" of the same interaction system as unorganized violence and number killed in domestic violence. More specifically, the concept of state variable implies, as discussed above (cf. p. 4), functional independence of variation within static time slices, and functional dependence of variation over-time. Again, the analysis summarized in Tables 5, 6 and 7 has failed to find any appreciable dependence of planned violence on the other two hypothetical state variables. One conclusion suggested is that a central assumption of the above analysis is incorrect. This assumption which is reflected in the lesser assumption that planned violence, unorganized violence and number killed in domestic violence are all state variables of the same interaction system, is that the nine domestic conflict variables analyzed here fall within the purview of a single interaction system. The fact that planned violence has little variation in common with the other two state variables isolated suggests that planned violence phenomena are caused by an interaction system separate from that causing unorganized violence or other domestic conflict phenomena.

An alternative interpretation of finding (1) which is favored on theoretical grounds is that the independence of time-variation observed among the state variables is an artifact of the assumptions built into the over-time analysis. Specifically, in the above a time-dependent, linear relationship among the state variables was assumed. This hypothesis is partly disconfirmed by finding (1) as unplanned violence is linearly independent of the other state variables. However, the possibility (which we have not been able to test) remains that if the over-time factor analysis had been performed utilizing some alternative function of the state variable, planned violence the required functional dependence of state variables with changing time would have been observed. Of course, this is no more than speculation, but it does seem preferable to the view that planned violence is totally unrelated to unplanned violence and that they are products of different systemic interactions.

Finding (2) listed above confirms the interdependence over-time of variation in the state variables unorganized violence, and number killed in domestic violence. However a) the fact that this interdependence is not described by the time functions incorporated in the factor analysis and

b) that finding (3) indicates that the time functions were totally unsuccessful in describing variation in any of the state variables means that the specific hypotheses advanced above relating to time variation are disconfirmed. One possible explanation why these hypotheses were disconfirmed is simply that they are fundamentally incorrect in their description of time-variation. A second explanation is available however, and relates to the methodological interpretation of the above results. These will now be presented.

3. Methodological Interpretation of Results

It will be recalled that factor analysis was viewed earlier as a means of confirming linear formulations implicit in over-time hypotheses about system-transition. The hypothesis guiding the over-time factor analysis just reported on incorporated the simple linear form assumption that all three state variables and "sine-time" would be a linear combination of one factor. The above results and their substantive interpretation indicate disconfirmation of this assumption, and of any alternative hypothesis viewing change in the state variables as a linear function of any of the four time functions used in the analysis, or their linear combinations. Thus, over-time variation in the state variables is not a function of sin t, nor is such variation a linear combination of either the set of four time functions or any subset of these functions. Hence the factor analysis has disconfirmed our explicit linear form assumption and in addition all alternative linear formulations implicit in simultaneous consideration of the interrelations between over-time variation in the three state variables and over-time variation in the four time functions. Normally, these results of the factor analysis would be sufficient to illustrate the methodological claim being advanced here; that over-time factor analysis can confirm (or disconfirm as the case may be) linear formulations implicit in hypotheses of system-transition. However, the second explanation for disconfirmation of the hypotheses guiding this study, which was alluded to in the section on substantive interpretation, casts doubt on the methodological validity of the above illustration. More specifically, correlations with the time functions, which may have confirmed the linear formulations hypothesized explicitly or implied in the analysis, may have been washed out by a peculiarity of the design of the over-time factor analysis. This last claim, of course requires further elucidation.

It will be recalled that the results do indicate a strong negative relationship between unplanned violence and number killed in domestic violence. In other words, relative to variations in time-sequence the above analysis shows that increases in unorganized violence are accompanied by decreases in number killed in domestic violence. On the other hand this pattern of variation shows no relation, either positive or negative over the 74 nations relative to increasing values of the four time functions. Now, this lack of correlation could be due to the presence of complex cyclic patterns of variation with time, in which case the explanation that the hypotheses are incorrect would apply. However, it is also possible that the lack of correlation is due to the specific factor analysis design utilized. This design tacitly assumes that all 74 nations are alike with respect to their positions in the interaction process of domestic conflict. Thus all nations are analyzed over nine time periods spanning the larger time period 1955-1966. What however, might be the results of such an analysis if 1955 is not "time 1" (or is not an "equivalent" time period) in the time-path of the interaction process of all nations? What for example would occur in an analysis such as the above if nations 1-37 were at "time 1" in their domestic conflict situation process in 1955 and nations 38-74 were at some unknown "time n" in theirs? In such a situation it seems plausible, for nations 1-37, that unorganized violence may increase throughout the 1955-56 time period while number killed in domestic violence decreases; and similarly that for nations 38-74 the converse may occur. This would produce, of course, a high negative correlation between the two state variables which exists separately in subsets

1-37, and 38-74, but it would also wash out a simple linear relationships with specific time change variables within the total set of nations 1-74. In a situation such as this of course, the explanation of faulty design would explain a lack of correlation between hypothetical time functions and state variables.

If such a design problem does exist, this in turn, suggests that a) revision in the strategy for systems analysis recommended here, and b) further illustration of the capability of factor analysis relative to confirmation of over-time linear formulations, are both necessary.

4. Summary

Summarizing the above findings and interpretations it seems that most of the hypotheses used to approach the over-time analysis are not borne out by the analysis. On the other hand there is one positive finding of great importance. This is the observed high interdependence of the state variables unorganized violence and number killed in domestic violence on a single time variation factor. Again, we have not been able to interpret this factor as all our hypotheses about the specific form of time variation in domestic conflict were initially disconfirmed. In the process of disconfirming the hypotheses however, we have come upon two possibilities which merit further investigation. First, a possible explanation for our negative findings is that there exists a fundamental weakness in the design for systems analysis presented earlier in that it does not take into account differences in the time paths of interaction processes characteristic of nations. Second, a possible explanation for our findings is that we merely require new hypotheses about patterns of time variation. Both of these possibilities are investigated below. Prior to this investigation however, it will be necessary to a) present a method for eliminating the possible design weakness identified and b) generate new hypotheses describing time-variation among the state variables.

e. Isolating Types of System Time Paths

Again, a possible weakness in the design for systems analysis is that it does not take into account differences in the time paths of interaction processes characteristic of the political units of analysis which in this specific instance are nations. Speaking broadly, three possibilities exist with respect to the question of differences in time paths of national interaction processes relating to domestic conflict. First, there may be no major differences in time paths. In terms specific to the analysis being carried out, 1955 may be precisely the same point-in-time for every nation vis-a-vis its domestic conflict interaction process. Second there may exist major differences in time-paths of interaction processes among groups of nations, but within these groups time-paths may be similar. Third, there may exist major differences in time paths of interaction processes for all nations.

Now if the first of the three situations distinguished obtains then the design employed above is correct as it stands. If either the second or third situations obtain however, the design is incorrect but can be revised as follows. If the second situation obtains the method of over-time factor analysis just employed should be applied to each group of nations having similar time-paths separately. If the third situation obtains then over-time analysis may be applied to each case separately in the manner discussed above, and illustrated in Figure 4.

Given the foregoing, the problem of revising the design presented earlier comes down to this: Find a quantitative method of typologizing time paths of the interaction processes of systems. Depending upon what the results are of application of the method the correct alternative strategy just indicated may be employed. The remainder of this section thus is devoted to exposition of a method for typologizing systems according to similarities in their time-paths.

The problem of isolating system types according to similarities of their time paths presents a good deal of difficulty. A number of techniques for typologizing systems in such a way as to accomplish our objectives were employed, and rejected as unsatisfactory. Finally the problem was conceptualized as follows. Our purpose was to find those systems or clusters of systems whose variance patterns over time were most similar to each other. Since in effect, the systems were represented by a set of time ordered state variable values it seemed that these problems could be solved by a factor analysis of a matrix whose rows were time periods or occasions, and state variable values, and whose columns were nations. Factor analysis of such a matrix would delineate those entities whose variation with increasing time over all state variable distributions exhibited a similar pattern.

This conclusion may be clearer to the reader after examination of Figure 7. If the columns of a matrix such as that in Figure 7 are intercorrelated, the correlations between any two columns will represent the extent to which variation in the columns exhibit a similar pattern. But since the columns are clearly national sets of factor score or state variable values over time and over all state variables it is also apparent that the extent to which two columns are similar to each other is the extent to which two nations are similar to each other in the overall variation of their state variables values with change in time. Thus, if a correlation matrix is computed from a matrix of the type illustrated in Figure 7, and this matrix is then factor analyzed, the result will be a factor loading matrix which delineates clusters of systems with similar time variations over all state variables (or in other words with similar time paths). It is just such clusters of system types that we need to isolate here.

The foregoing then is our suggested method of typologizing systems according to similarities in their time paths. It now remains to apply this method to the concrete investigation being carried out here, and to indicate

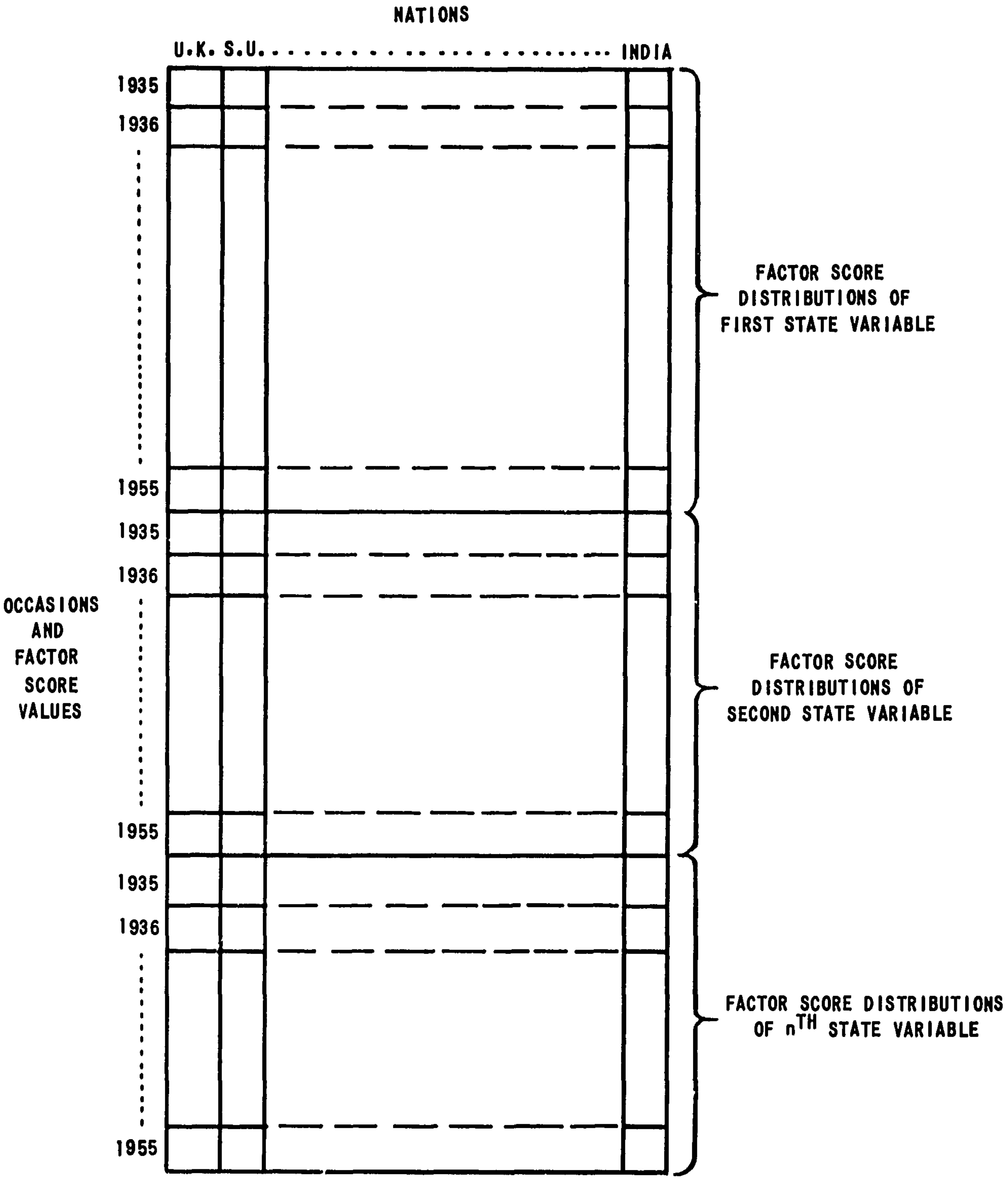
NATIONS
U.K.
S.U.
INDIA
1935
1936
1955
1935
1936
1955
1935
1936
1955
OCCASIONS AND FACTOR SCORE VALUES
FACTOR SCORE DISTRIBUTIONS OF FIRST STATE VARIABLE
FACTOR SCORE DISTRIBUTIONS OF SECOND STATE VARIABLE
FACTOR SCORE DISTRIBUTIONS OF n^{TH} STATE VARIABLE

Figure 7 A NATIONS - OCCASIONS - FACTOR SCORE (STATE VARIABLE) VALUE MATRIX

the implications of the results for further analysis of domestic conflict time variations. Accordingly the factor scores produced by the state variable analysis discussed earlier were arranged for the 74 nations and nine time periods in our sample in the manner of Figure 7. The columns of the resulting nations - time periods - state variable matrix were intercorrelated and factor analyzed. Both orthogonal and oblique simple structure rotations were carried out on the factor solution. The resulting factor loading matrices will not be reproduced as they are somewhat unwieldy and have little interpretive values for the present analysis. The following remarks however, should adequately summarize our results. Fifteen factors appeared with eigenvalues of $\geq$ 1.0. These accounted for approximately 92.7% of the variance in the data matrix. Orthogonal rotation indicated that the last five of the 15 factors grouped no more than one nation each. These factors were eliminated from the final oblique rotation, and 10 factors accounting for 82.5% of the variance were retained. Table 8 gives the make-up of each group, along with the factor loadings measuring the extent of correlation of each nation with the factor defining the group. The table also lists those nations in the sample which were not grouped successfully by the method employed. It should be noted that 62 of the 74 nations were grouped successfully.

The above typological analysis of system time-paths relating to domestic conflict processes indicates that 10 groups of nations, some small, and some large contain nations with time-paths similar to one another. Twelve nations do not exhibit time path similarities with other nations. The implications of this finding for our analysis of domestic conflict time variations is that attempts to check the linear forms in hypotheses about time variation through factor analysis should have proceeded by first separating nations into the ten similar groups delineated above. Without performing factor analyses on each group it is impossible to tell whether over-time hypotheses have been disconfirmed as a result of time-path differences among cases, or whether something more fundamental is amiss. Consequently, group-separate over-time factor analyses were performed to correct the initial error in our approach. The results of these group analyses will be summarized below. First, however, the issue of new hypotheses for description of over-time variation in domestic conflict will be discussed.

Table 8

Time Path Similar Groups of Nations

	1		2		3		4		5		6		7		8		9		10		UNC
Nations	AFG	.94	CAM	.82	BRA	.60	BOL	.78	ITA	.82	CAN	.92	BEL	.79	COL	.84	IND	.72	IRN	.89	ARG.
	ALB	.99	ELS	.84	BUL	.55	CEY	.67	PAK	.78	GRC	.70	NEP	.70	GUA	.54	SPN	.84	URU	.64	BURMA
	AUL	.94	HON	.56	CUB	.54	SAU	.70	PAR	.74	UNK	.82	TUR	.87	HAI	.60	USA	.55			CHL
	CHT	.84	JAP	.89	DOM	.52	TAI	.86	PHI	.60											CHN
	COS	.66	LEB	.94	ECU	.92															FRN
	CZE	.94	MEX	.87	INS	.80															HUN
	DEN	.99	NIC	.84	POL	.62															IRQ
	ETH	.58	PAN	.57	POR	.65															JOR
	FIN	.83	UNS	.78																	KOS
	GME	.99																			LBR
	GMW	.77																			PER
	IRE	.93																			VEN
	ISR	.51																			
	KON	.52																			
	NTH	.70																			
	NEW	.99																			
	NOR	.90																			
	OUT	.79																			
	RUM	.77																			
	SWD	.90																			
	SWZ	.89																			
	USR	.70																			
	YUG	.75																			
TOTAL	23		9		8		4		4		3		3		3		3		2		12 = 74

f. New Hypotheses Describing Over-Time Variation

The results of the first over-time analysis could well be interpreted, as pointed out above, as a disconfirmation of the hypotheses about time-transition in the state variables built into the research design. If this interpretation is correct, it implies, in turn, that over-time factor analysis can, as we have claimed, be utilized to check the linear forms implicit in over-time hypotheses. Thus, in the example, it was hypothesized that the three state variables would prove to be linearly dependent on each other and also on one of the four time functions included in the analysis. The results, once again, indicated that unorganized violence, and number killed in domestic violence were mutually dependent, but not planned violence or any of the time functions.

In order to demonstrate that results such as the above do indicate that over-time factor analysis is effective in checking linear form assumptions it would be best to obtain results from such factor analyses which positively confirmed known linear form assumptions implied in over-time transition hypotheses. Results disconfirming hypotheses, such as those already obtained, can easily be attributed to specific peculiarities of a factor analysis design (such as the possibility of differences in time-path variations among systems also being considered here), or even to the inappropriateness of factor analysis as a technique for checking linear form assumptions. If we are able to obtain, on the other hand, results which confirm known linear form assumptions built into an over-time analysis we then have a much more convincing illustration of the usefulness of factor analysis in this regard.

Accordingly, it was decided to employ a curve-fitting method to generate inductive hypotheses from the factor score data for each of the similar time-path groups isolated above. While there was no guarantee that such a method would yield functions that fit the factor score data well, curve-fitting techniques at least allow measurement of how well a model used in fitting a curve to data actually fits that data. In instances where the curve-fitting is successful vis-a-vis the factor score data representing the distribution of a state variable, one could expect that a subsequent factor analysis would confirm a linear model showing high interdependence between the state variable and the function used in the curve-fitting (see the next section for this analysis). Conversely, in instances where the curve-fitting is unsuccessful vis-a-vis the factor score data, one could expect that a subsequent factor analysis would disconfirm a linear model showing high interdependence between the state variable and the curve-fitting function.

Thus, the use of curve-fitting to derive new hypotheses appears preferable in the present context to the earlier procedure of arriving at hypothetical time functions to include in the over-time analysis by intuition alone. Since it was still felt that over-time variations in the state variables were likely to be cyclic in character, and also because resources were available to perform only one extensive curve-fitting analysis, the decision was made to employ the BMD04R Periodic Regression and Harmonic Analysis Program[19] as a curve-fitting method.

This program performs periodic regression and harmonic analysis using regression functions of the form

$$x_t = \bar{x} + \sum_{i=1}^{n} \left(\alpha_i \cos\left[\frac{i2\pi t}{K}\right] + \beta_i \sin\left[\frac{i2\pi t}{K}\right]\right)$$

In the above equation:

x_t = The value of a designated variable x at some point in time t.

$\bar{x}$ = The mean of value of x over the time series being fitted.
n = The number of harmonics used to fit the time series.
i = The number of a particular harmonic.
α_i and β_i = Regression coefficients for the i^{th} harmonic.
K = The number of time periods in the time series.
t = A specific time period.

The statistical model employed in the computational procedure is stated in the program description in slightly different though equivalent form to the above.

> "The statistical model requires the assumption that Y_{rt} was observed at $x_t = 2\pi t/K$. Harmonic analysis of this series consists in the fitting by least squares" (italics added) "the regression function
>
> $$Y_t = a_o + \sum_{j=1}^{n} [a_j \cos(jtc) + b_j \sin(jtc)]$$
>
> having 2n + 1 regression coefficients" (italics added)
>
> "$a_0, a_1, a_2, \ldots a_n; b_1, b_2, \ldots b_n$ where $c = \frac{2\pi}{K}$ converting the t to radian measure. A constant number "m" of observations y_{rt} (r=1,2,3...,m) is taken at each value of x_t(t=o,1,2,...,K-1)."

The summary statement just quoted of the statistical model employed in the BMD04R program, indicates an aspect of the computation model of great salience to this analysis. Specifically, the model employed is similar in some respects to the multiple regression model which, of course, is much more familiar to political scientists. Thus, the computation procedure yields 2n+1 regression coefficients such that the resulting equation minimizes the squared deviations of the actual values in the time series from the values "predicted" by the regression equation. However, it is important to emphasize that the regression procedure employed differs from that characteristic of multiple regression in that no fixed number of terms is assumed at the start. Rather the regression equation is expanded through the successive addition of new harmonics until an equation satisfactory to the analyst, that is one which accounts for some satisfactory portion of the total variance in the time series is obtained. The addition of each new harmonic introduces two new terms into the regression equation. These, of course, are accompanied by two new regression coefficients.

Other aspects of the BMD04R program salient to this analysis are as follows. First, the program operates on groups of cases, each case having a time series. Regression coefficients are computed for each case by the program. However, the only results printed out are those for an "average" case representing each group analyzed. In applying the BMD04R program in the present context, successive applications were made to each of the ten groups of nations having similar time-paths identified in the preceding section. Also harmonic functions representing an average for each of the groups were then derived from the analysis.

Second, the program also provides an analysis of variance relating to the harmonic regression. Among the components of the analysis of variance are: a) the amount of total variation accounted for by the harmonic function fitted to the "average" data case and b) the total variation (sum of squares) contained in the data set for each group. The ratio of a/b is a measure of how much of the variation in the total data set (b) is accounted for by (a). This ratio is also equivalent to the square of the product-moment correlation between the predicted and actual values for every case (of the time varying state variable being analyzed); where the predicted values are derivable from the harmonic function fitted to the average data case.[20]

The implication of this equivalence between a/b and the square of the product moment correlation between the predicted and actual values of state variables is that factor analysis must succeed in confirming the hypotheses of time variation suggested by the harmonic analysis. For, the extent to which these hypotheses actually fit the data, and hence constitute promising components of a linear model, is measured by the ratio a/b. But a/b is equivalent once again to the square of the product moment correlation between the predicted and actual values of the state variable in question. Of course, it is just these product moment correlations which provide the raw material for the factor analyses of over-time data still to be reported on. And finally, therefore, since the factor analyses can only serve to extract the patterns of intercorrelation from the predicted and actual values of time-varying state variables the results of the factor analyses must be consistent with the hypotheses suggested by the harmonic analysis.

We now turn to the results of the harmonic analysis performed on time variation of each of the three state variables, planned violence, unorganized violence, and number killed in domestic violence. Once again, separate analyses were performed for each of the ten groups of nations having similar time paths. Thus, harmonic analysis of the three state variables for each of the ten groups yielded 30 harmonic time functions as candidates for the factor analysis to follow. Table 9 below presents for each set of state variable values within each group the regression coefficients derived from the harmonic analysis, the sum of squares associated with each harmonic and hence each pair of regression coefficients, the sum of squares associated with total variation of the state variable, and the % of total variation in the state variables.

A few remarks are necessary to aid readers in interpretation of the harmonic analysis results. First, it should be noted that the groups of nations utilized in the above analysis and in the factor analysis to follow are not identical with those resulting from the analysis of system time paths and listed in Table 8. More specifically we excluded through processing errors, China (Taiwan), Ethiopia, Israel and North Korea from group 1, and an unknown nation among the three in group 8. In addition one of the four nations in group 4 was inadvertently shifted into group 5 and again we do not know the identity of this nation.

While the classification errors just listed have undoubtedly effected both the harmonic and factor analyses to some extent, they are minor in their methodological significance for this illustration of the usefulness of factor analysis for studying time-variation in state variables. Thus, we have made no attempt to correct our errors, and merely inform the reader of their existence.

TABLE 9

Harmonic Analysis of 3 Time Varying State Variables*
In Each of 10 Groups of Nations Having Similar Time Paths

Group Number	State Variable	First Harmonic			Second Harmonic			Third Harmonic			Total Sum of Squares	Percent Variation Due to Harmonic Function	Group Size
		Regression Coefficients		Sum Squares	Regression Coefficients		Sum Squares	Regression Coefficients		Sum Squares			
		α_1	β_1		α_2	β_2		α_3	β_3				
1.	Planned violence	- 01	- 01	0 03	- 10	- 12	2 04	10	- 01	0 93	137 00	2.3	19
1 2.	Unorganized violence	- 01	04	0 15	04	05	0 34	- 15	01	2 02	136 01	2.0	
3	Number killed	06	- 05	0 54	- 03	- 16	2 14	02	- 10	0 96	136 00	2 6	
4	Planned violence	- 20	39	7 85	- 43	- 58	21 27	51	03	10 72	72 00	54 8	9
2 5	Unorganized violence	- 09	32	4 52	- 23	- 23	4 28	34	17	5 99	72 00	20 3	
6	Number killed	16	- 51	11 73	21	52	12 83	- 64	- 00	16 49	72 00	57 2	
7	Planned violence	02	- 59	12 72	- 56	- 30	14 76	- 16	46	8 53	64 00	56.3	8
3 8	Unorganized violence	09	19	1 55	08	- 06	0 34	- 09	- 41	6 31	64 00	13 0	
9	Number killed	06	- 80	23 44	- 18	- 31	4 52	- 23	19	3 19	63 99	49.0	
10	Planned violence	- 42	- 54	6 41	- 83	23	10 08	51	12	3 77	24 00	84.6	3
4 11	Unorganized violence	40	06	2 18	24	13	1 04	- 40	19	2 61	24 00	24.0	
12	Number killed	- 36	- 18	2 21	- 25	- 27	1 85	25	- 16	1 19	24 00	22.1	
13	Planned violence	27	14	2 08	- 04	- 42	4 02	83	- 25	16 96	40 00	57.2	5
5 14	Unorganized violence	- 37	- 08	3 22	- 14	- 09	0 61	- 51	13	6 29	39 99	25.0	
15	Number killed	28	- 10	2 02	55	08	6 91	48	22	6 33	40 00	38.4	
16	Planned violence	- 09	- 80	8 84	07	- 58	4 56	- 51	- 28	4 59	24 00	75.7	3
6 17	Unorganized violence	- 20	- 47	3 51	- 35	- 54	5 63	- 28	51	4 66	24 00	57.2	
18	Number killed	- 44	29	3 73	- 19	61	5 43	23	62	5 95	24 00	62.4	
19	Planned violence	- 43	09	2 65	- 27	- 47	4 03	61	- 13	5 20	24 00	49.0	3
7 20	Unorganized violence	- 22	08	0 73	35	20	2 14	- 29	- 08	1 20	24 00	16.8	
21	Number killed	08	54	3 98	- 35	- 78	9 97	47	11	3 21	24 00	72 3	
22	Planned violence	14	13	0 32	- 79	- 13	5 84	- 47	- 63	5 56	16 00	74.0	2
8 23	Unorganized violence	14	64	3 88	- 56	63	6 42	- 50	- 40	3 68	16 00	88 4	
24	Number killed	- 26	- 52	3 06	54	- 62	6 11	41	24	2.03	16 00	70.6	
25	Planned violence	- 06	32	1 46	06	28	1 12	34	22	2 17	24 00	20.3	3
9 26	Unorganized violence	29	- 75	8 71	- 08	- 42	2 47	- 51	- 19	3 92	24 00	62.4	
27	Number killed	- 10	- 44	2 77	- 25	- 14	1 13	--	--	--	24 00	13.0	
28	Planned violence	12	- 54	2 78	- 35	- 22	1 54	24	56	3 35	17 00	47.6	2
10 29	Unorganized violence	- 25	- 06	0 61	- 27	- 54	3 25	- 27	.75	5 80	16 00	58.8	
30	Number killed	- 05	34	1 08	- 68	39	5 56	-.01	- 44	1 72	16.00	51.8	

*Factor scores for each nation-set of sequentially arranged time slices were separately standardized as in the earlier time transition analysis

Second, a word is appropriate on interpretation of the above table. Earlier in this section the harmonic analysis - periodic regression model was stated as:

$$x_t = \bar{x} + \sum_{i=1}^{n} (\alpha_i \cos[\frac{i2\pi t}{K}] + \beta_i \sin[\frac{i2\pi t}{K}])$$

The table presents the coefficients necessary to express the particular specifications of this model fitted to each state variable distribution within each of the groups of nations. In addition, for each specification of the model, the table presents a measure of the extent to which the model specification accounts for the variation in the state variable. For example, the first state variable distribution in group 1, that is planned violence, is described by the following equation (according to the results of the harmonic analysis).

$$\text{Planned violence}_t = x_t = \bar{x} - .01 \cos(\frac{1 \cdot 2\pi t}{9})$$

$$-.01 \sin(\frac{1 \cdot 2\pi t}{9}) \quad -.10 \cos(\frac{2 \cdot 2\pi t}{9})$$

$$-.12 \sin(\frac{2 \cdot 2\pi t}{9}) \quad +.10 \cos(\frac{3 \cdot 2\pi t}{9})$$

$$-.01 \sin(\frac{3 \cdot 2\pi t}{9})$$

Since the state variable distributions were separately standardized (as in the earlier time-transition analysis) for each nation-set of sequentially arranged time-slices, $\bar{x} = 0$ and can be neglected in the above expression and in the other 29 equations which can be derived from the table. It should also be noted that numerical values in the above equation other than the regression coefficients in the table follow rather obviously from the general model cited earlier. Thus referring again to that model, i = the number of particular harmonics accompanying the pairs of regression coefficients, in this instance 1, 2, and 3; and k = the number of time periods in the time series for each nation, in this instance 9. Finally, the table indicates that the specification of the harmonic analysis model just described is not very successful in accounting for time-variations in planned violence for all 19 nations comprising group 1. More specifically, the above equation only accounts for 2.3% of the over-time variation in planned violence occurring in group 1.

In light of the above considerations it should be clear that each line of Table 9 represents an equation which accounts for some specified extent of the over-time variation in the state variable distributions extant within a group. Moreover, each equation is a complex function of the time. We will not write all the equations implied by the above table. We merely note that there are 30 such equations and complex time functions. Some fit their corresponding state variable distributions well, some not so well. The variation in closeness of fit provides an opportunity for systematic illustration of the relevance of factor analysis in testing linearity assumptions present in over-time hypotheses. Thus, depending on the closeness of fit of each time function to each state variable it is possible to specify whether factor analysis should confirm or disconfirm particular linear hypotheses, and then compare the actual results of the factor analyses performed to test these hypotheses. Details of the hypotheses to be tested and their relation to the harmonic analysis results just presented are contained in the next section along with results of the factor analyses of over-time data performed for each of the 10 groups of nations having similar time-paths. Before presenting these details however, a final issue must be considered.

Since, as shown above (p. 50), the factor analysis must succeed in confirming the linear form hypotheses emerging from the harmonic analysis, it is relevant to digress at this point and raise the question of why it is useful to proceed further with this illustration beyond simply reporting the results of the harmonic analysis. There are a number of reasons why proceeding with a description of the group factor analyses is useful.

First, under some research conditions, it may be neither desirable nor feasible to employ curve-fitting techniques to generate over-time hypotheses. If such a situation applies and hypotheses of time-variation have been derived either through intuition or through the application of a rigorous theoretical model researchers may wish to move directly to a test of their linear form hypotheses through computation of correlation and factor matrices for both time-varying state variables and hypothetical time functions. We have already illustrated how this may be done through the initial over-time analysis reported on above. Other examples of application of this methodology are also useful, however.

Second, though knowledge of how well the harmonic time functions which emerge from this stage of the analysis fit with the actual data distributions of each of the time-varying state variables is given by the harmonic analysis itself, this analysis gives no indication of the linear interdependence among the state variables and the different harmonic time functions fitted to each one. The results of the factor analysis to be described will answer this question of linear interdependence.

Third, description of the factor analysis performed on each group will provide an opportunity for precise illustration of how the non-linear harmonic analysis results might be translated into relevant linear hypotheses appropriate for testing through factor analysis. We will thus be able to further articulate the issue of how non-linear functions may enter into linear formulations.

Finally, reporting the factor analysis results is necessary for full delineation of the plasmode being developed here. The purpose of this over-time analysis is after all to illustrate how factor analysis confirms or disconfirms linear-form assumptions implicit in overt-time hypotheses. We now know that factor analysis must succeed in testing the linearity assumptions emerging from harmonic analysis of state variable variation. It is still necessary to explicate fully how such testing is accomplished.

g. Further Time-Transition Analysis

1. Hypotheses

The initial results and interpretation of the domestic conflict time-transition analysis indicated disconfirmation of the original admittedly vague hypotheses about patterns of variation in the state variables with changing time. The analysis was not felt to be entirely convincing however in its illustration of the usefulness of factor analysis for checking linear-form assumptions present in hypotheses about time variation. Three possible reasons for the unconvincing nature of the analysis performed earlier were emphasized. First, it was reasoned that differences in system time paths among nations may have caused a blurring of linear relationships consistent with the hypotheses and that in fact one or more of these might be valid. Second, it was suggested that the hypotheses might in fact be incorrect and that alternative formulations of time functions were needed to account for over-time variation in state variables. Third, in the context of the discussion of how new and more complex time functions might be formulated, it was pointed out that the initial results might be unconvincing because they disconfirmed the hypotheses formulated, and because such results can more early be attributed to the inappropriateness of factor analysis for checking linear form assumptions.

We have set out in the sections preceding this one to remove the three obstacles to a convincing illustration of the usefulness of factor analysis for viewing time transitions just described. The first obstacle, that is the possibility that differences in system time-paths blur relationships can be taken into account by a) typologizing the 74 nations according to their similarities in over-time variation and b) then performing a separate time-transition factor analysis of the type carried out above for each group of nations having similar time paths. Of course we have already reported the results of an attempt to typologize the 74 nations on the basis of time-path similarity. In this section we will report the results of the separate time-transition factor analysis performed for each group of nations identified.

The second and third obstacles to the success of our illustration we have attempted to overcome by generating new time function hypotheses for each of the groups of nations having similar time paths through harmonic analysis. The harmonic analysis generated three new time function hypotheses for each of the ten groups or a total of 30 new hypotheses. All fulfill the requirement of greater complexity. Further, the results of the harmonic analysis include a measure of the closeness of fit of each of the 30 hypotheses to the actual distributions of state variables. Thus, it is possible to know in advance which time functions ought to be effective in accounting for variations in the state variables and which ought not to be. The results of the factor analyses to be reported on in this section should be consistent with the findings of the harmonic analysis if this illustration of the usefulness of the factor model in over-time analysis is to be convincing.

Moving to the specifics of the over-time factor analyses, it should again be emphasized that we will be reporting on ten such analyses, one for each group of nations having similar time paths. For each group of nations the relevant data matrix will be comprised of the following variables.

(a) The three state variable distributions of factor scores for the original time-slice factors, planned violence, unorganized violence, and number killed in domestic violence are included. As in the earlier over-time factor analysis these distributions have been separately standardized within each set of sequentially arranged time slices associated with each nation of the group. Thus, magnitudes associated with cross-national variation in the factor score distributions have been removed, and only the variation due to changing time remains.

(b) The variable time was also included in the factor analyses. The reason for this was to investigate the possibility that simple functions of time can account for time-variations in the state variables provided that care is taken to control for differences in system time-paths.

(c) The three time functions emerging from the harmonic analysis of each group, or more precisely the state variable distributions predicted by these functions, were also included in each of the factor analyses. It should be borne in mind that these functions differ for each group of nations and for each state variable distribution. Thus there are 30 such functions in all.

Keeping the above data matrix in mind we specify the following hypotheses to be tested by the various factor analyses.

(a) The state variable distributions are linearly interdependent over time. This hypothesis is suggested by the assumption that the three state variables are properties of the same systemic interaction. The initial time-transition analysis reported on earlier disconfirmed this hypothesis. However there is a possibility that the disconfirmation was due to the time-path dissimilarity factor discussed above. Consequently we offer the hypothesis once again in this context.

(b) One or more of the state variables will be highly correlated with the time variable (t). This is another hypothesis tested and disconfirmed earlier, whose disconfirmation may have been due to time-path dissimilarity among nations.

(c) Harmonic analysis results presented in Table 9 provide three new hypotheses, for each of the ten groups of nations, relating each state variable to a harmonic function of time. Along with each of the hypotheses is given a measure of the linear fit of each harmonic function to its corresponding state variable (as indicated by the column in Table 9 headed by "% variation due to harmonic function"). For purposes of this discussion it suffices to classify these "fits" into "good," "intermediate" and "poor". We define a good linear fit as a circumstance where more than 50 % of the variation in the state variable is associated with the variation in the harmonic function (this corresponds to a product moment correlation of approximately .71). A "poor" linear fit is defined by us as one in which less than 25% of the variation in a state variable is associated with the harmonic function (product moment correlation less than .50).

Though we might expect the state variables and their corresponding harmonic functions to define time-transition factors in instances where the linear fit between the two is "good," and to fail to define such factors where the linear fit is classified as "intermediate" or "poor," the situation with respect to confirmation of our linear form assumptions through factor analysis is not that simple.

Linear fits intermediate between those defined as "good" and those defined as "poor" may result in a factor defined by "high loadings" of a state variable and its corresponding harmonic function. The chances of this happening are correspondingly greater, the closer the particular "intermediate" linear fit is to a "good" fit. It is even possible on rare occasions for linear fits classified as "poor" to result in a factor defined by high loadings of both a state variable and its harmonic function.

The reason why linear fits classified as "intermediate" and "poor," may under certain conditions define over-time factors is the phenomenon of "straddling" of factors. The straddling phenomena may best be illustrated through the following hypothetical example depicted in Figure 8.

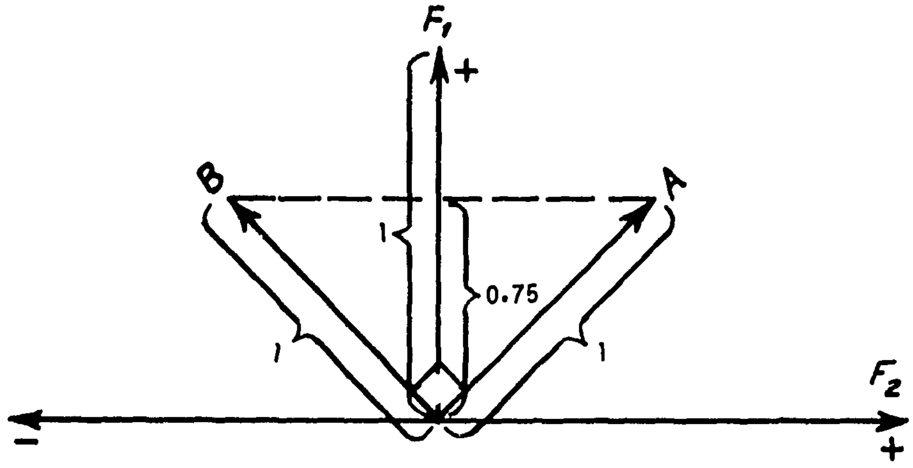

Figure 8 "FACTOR STRADDLING"

Here Factors F_1 and F_2 span a vector space of normalized vectors of unit length 1. Vectors A and B which "straddle" F_1 are uncorrelated, that is the angle θ between them is 90°, and cosine θ which in this instance is equivalent to the correlation between the two vectors is 0. Though vectors A and B are uncorrelated with each other, they are both correlated rather highly with F_1 and F_2. In fact as the diagram shows the Factor Loading (or correlation) of both A and B relative to F_1 is identical and is equal to +.75.

Thus, though a "poor" linear fit exists between A and B, the two vectors exhibit identical factor loadings relative to F_1, because of the position of F_1 in the vector space.

Since the "straddling" phenomenon means that "intermediate" and "poor" linear fits as well as "good" ones may at times define over-time factors, it is clear that we cannot utilize the occurrence of such time-transition factors alone as the test of our linear form assumptions. On the other hand if the occurrence of an over-time factor defined by some variables is not a sufficient condition for concluding that a strong linear relationship exists between them, it is at least a necessary one. Thus, the occurrence of an over-time factor defined by high loadings of a state variable and its corresponding harmonic function will be one criterion for judging whether the results of the various factor analyses are consistent with the information about linear relationships emerging from the previous harmonic analysis. In this context a "high" factor loading is defined as $\geq |.71|$.

The second criterion we will use for judging the consistency of the factor analysis with the previous harmonic analysis is suggested by further examination of the "factor straddling" example given above. Figure 9 is an expanded version of Figure 8, now containing 3 vectors A, B, and C. Vector C is coincident with Vector A, and hence is also uncorrelated with Vector B, but has the same loading (.75) on F_1 as do Vectors A and B.

Simply from viewing the factor loadings of A, B, and C, on F_1 it is impossible to tell that Vectors A and B are uncorrelated with each other while Vectors C and A are perfectly correlated. Again, this is the typical interpretation problem introduced by factor straddling. However if we broaden our view of the interrelations among the three variables to include the pattern of loadings on both F_1 and F_2, we observe that the pattern of factor loadings (see Table 10 and Figure 9) associated with Vectors A and C is different from that associated with Vector B. More specifically, the factor loading of B on F_2, while of the same magnitude as those of A and C on F_2 differs in sign.

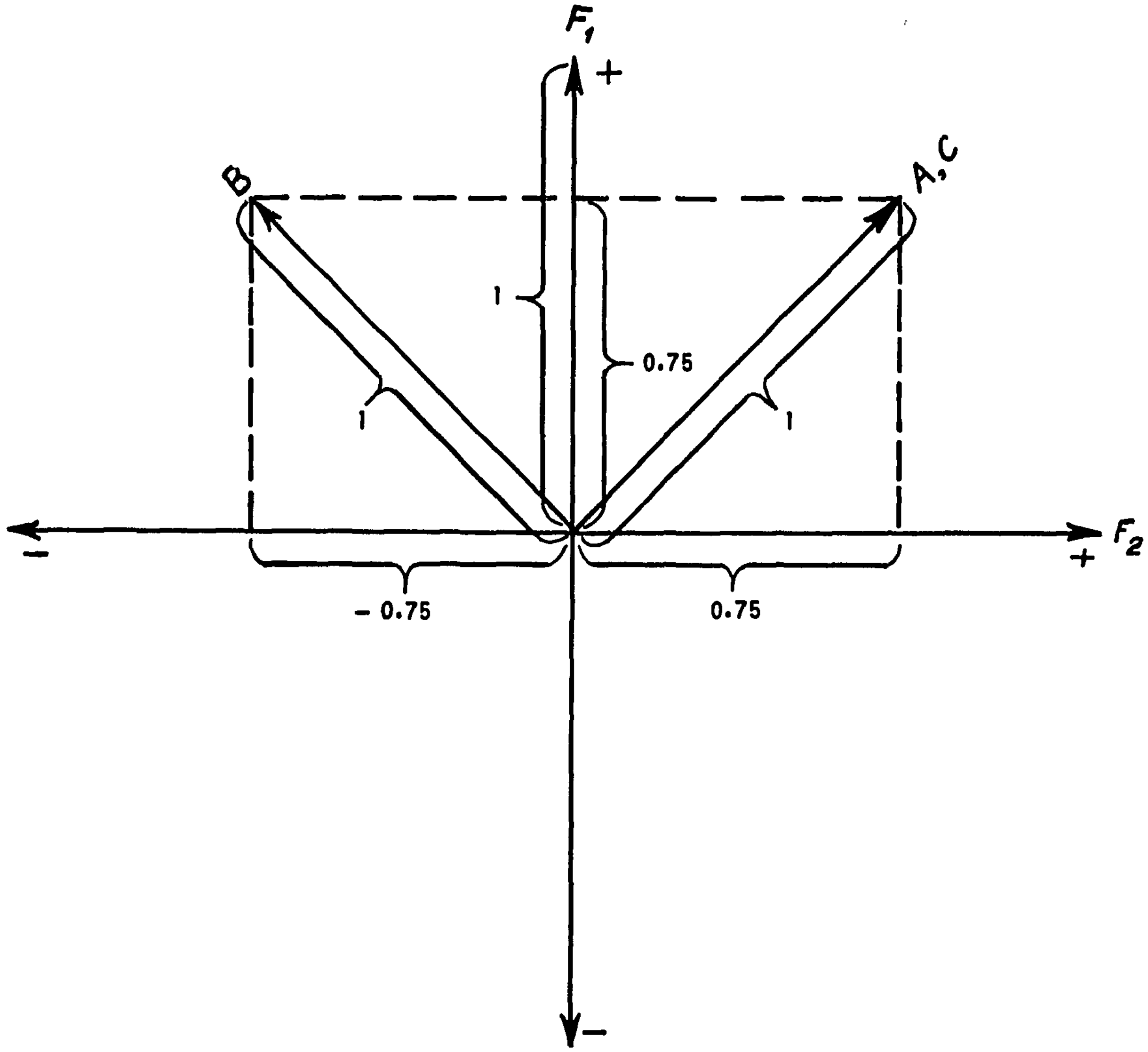

Figure 9 FACTOR "STRADDLING" WITH THREE VECTORS

Table 10 Factor Matrix Illustrating Straddling

Variables	Factors	
	F_1	F_2
A	.75	.75
B	.75	-.75
C	.75	.75

From the geometric interpretation contained in Figure 9 it can be seen that this difference in sign reflects the different location of Vector B relative to the other two vectors, and therefore its lack of correlation with these vectors. Conversely, the identity in the pattern of loadings associated with vectors A and C reflects their perfect correlation or linear relationship with each other.

The second criterion which we will use for judging the consistency of the factor and harmonic analyses then, is similarity in the pattern of factor loadings of state variables and corresponding harmonic functions occurring on factors other than the over-time factors these variables define. If the pattern of factor loadings is similar this will indicate that the over-time factor defined by the variables is a bonafide functional unity determined by variable clustering. If the pattern of factor loadings is different this will indicate conversely, that the particular over-time factor is an artifact of application of the mathematical construct and has been produced by "straddling".

Our hypotheses as derived from the harmonic analysis are as follows: Strong linear relationships between state variables and harmonic functions will be confirmed by the factor analyses in connection with relationships 4, 6-7, 10, 13, 16-18, 21-24, 26, 29-30 of Table 9. Such relationships will be disconfirmed in connection with relationships 1-3, 5, 8, 11-12, 20, 25 and 27. Lastly, relationships 9, 14-15, 19, and 28 are of intermediate strength according to the harmonic analysis. The relevant factor analyses may define both over-time-factors and similar patterns of loadings in these instances.

The chance of this occurring in the instance of relationship 14 is small because the linear fit (% of variation accounted for = 25%) is relatively "poor". It is correspondingly higher however, in the remaining instances because the linear fits there more closely approach the "good" category.

2. Summary and Interpretation of Results of Over-Time Factor Analyses of Nation Groups with Similar Time Paths

The results of the ten over-time factor analyses are quite extensive. A complete presentation and discussion of them involves a good deal of repetition and moreover is not necessary for purposes of adequate illustration of the methodology for systems analysis being proposed here. This section thus, will describe the results of one of the ten group factor analyses in order to illustrate how hypotheses a), b), and c) above were tested. Following this, a summary and interpretation of the results of all ten analyses will be presented. Tables containing complete results of the ten analyses have been included in Appendix B.

i. Group 2 Factor Analysis

Tables 11, and 12, are the correlation and factor loading matrices of the three domestic conflict standardized factor score and four hypothetical time function variables for the 9 group 2 nations named in Table 8. We have chosen to present the results of this group 2 analysis for illustrative purposes, because, in contrast to the initial over-time analysis described

TABLE 11

Correlation Matrix of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 9 Group 2 Nations

(Factor scores were separately standardized for each nation set of sequentially arranged time slices.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	.37	1.00					
3. Number killed in domestic violence	-.79	-.51	1.00				
4. Time	-.09	-.09	.23	1.00			
5. Planned violence P_{II}[a]	.74	.42	-.72	-.16	1.00		
6. Unorganized violence P_{II}	.69	.45	-.70	-.40	.93	1.00	
7. Number killed P_{II}	-.71	-.42	.76	.36	-.96	-.93	1.00

---

[a] Planned violence P_{II}, unorganized violence P_{II}, and number killed P_{II} are the harmonic analysis functions of time whose derivation is described in the preceding section. The Roman numeral indicates that the harmonic functions are those appropriate for Group II.

TABLE 12

Factor Loading* Matrices of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Functions for 9 Group 2 Nations

(Standardization of nation sets of sequentially arranged time slices carried out separately.)

Variables	Unrotated factors[a] 1	Unrotated factors[a] 2	h^2	Orthogonally rotated factors[b] 1	Orthogonally rotated factors[b] 2
1. Planned violence	(-.83)	.25	.75	(-.87)	.07
2. Unorganized violence	(-.57)	.26	.39	(-.61)	.13
3. Number killed in domestic violence	(.87)	-.13	.77	(.87)	.06
4. Time	.34	(.91)	.94	.14	(.96)
5. Planned violence P_{II}	(-.94)	.09	.88	(-.94)	-.11
6. Unorganized violence P_{II}	(-.94)	-.15	.91	(-.89)	-.34
7. Number killed P_{II}	(.95)	.10	.92	(.91)	.30
Percent total variance	65.0	14.4	79.4	63.0	16.5
Percent common variance	81.9	18.1		79.3	20.8
Eigenvalues	4.55	1.01			

* Loadings $\geq |.50|$ are given in parentheses

a. Principal axis method with unitities in principal diagonal of correlation matrix.

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

earlier, these results are illustrative of the manner in which factor analysis may support rather than disconfirm over-time hypotheses relating time functions to state variables.

The orthogonally rotated factor matrix (Table 12) indicates a high degree of linear interdependence among two of the three state variables; more specifically, planned violence and number killed in domestic group violence. This relationship stands in contrast to the interdependence of unorganized violence and number killed in domestic group violence observed in the initial over-time factor analysis which included all 74 nations. The observed relationship partially supports, as did the earlier result, hypothesis (a), which specifies that state variable distributions be linearly dependent over-time.

Hypothesis (b), that one or more of the state variables would be highly correlated with the time variable is emphatically disconfirmed by Table 12 which clearly identifies Factor 2 as specific to this variable.

Hypothesis (c), above is really a label for a series of 30 hypotheses derivable from the harmonic analysis. Three of these hypotheses relate to Group 2 nations. More specifically, strong linear relationships between the state variables, planned violence, and number killed in domestic violence on the one hand and their corresponding harmonic functions on the other were predicted for relationships 4 and 6 of Table 9. The third hypothesis specifies that a strong linear relationship will not be indicated for relationship 5 of Table 9 between unorganized violence and its corresponding harmonic function.

Table 12 confirms all three hypotheses. Thus, Factor 1 is defined by the three harmonic functions, which interestingly exhibit a high linear interdependence. Moreover, planned violence and number killed in domestic violence are also highly loaded on this factor, confirming relationships 4 and 6 just mentioned. Finally, the third hypothesis derived from relationship 5 of Table 9 is also confirmed as the factor loading of the state variable unorganized violence on Factor 1 falls short, as expected, of the earlier specified high level ($\geq |.71|$).

ii. Summary and Interpretation of Results

Having illustrated with the Group 2 results the mode of interpretation utilized in connection with the ten group factor analyses we may now briefly outline our over-all results. First, all three state variables were not generally found to be mutually interdependent over-time as initially hypothesized. An exception to this statement was observed in connection with the Group 1 factor analysis results. Here state variable 2, unorganized violence, exhibited moderate negative interdependence with both state variable 1, planned violence, and state variable 3, number killed in domestic violence. Results of the Group 2, 3, 4, 8, 9 and 10 factor analyses all exhibited mutual interdependence at either a moderate or high level of 2 of the 3 state variables. Which 2 of the 3 state variables and whether the linear interdependence observed was positive or negative in direction varied from group to group. Thus Group 2 exhibited high negative interdependence of state variables 1 and 3; Group 3 moderate positive interdependence of variables 1 and 3; Group 4 high positive interdependence of 2 and 3, Group 8 high negative interdependence of 2 and 3; and Groups 9 and 10 moderate negative interdependence of 1 and 3. Lastly, the results of the Group 5, 6 and 7 factor analyses all exhibited low interdependence among all 3 state variables. In sum, the picture with respect to interdependence among the state variables exhibits little regularity from group to group.

Second, the hypothesis that the time variable would be highly correlated with the state variables was also generally disconfirmed. A clear exception to this statement was recorded in connection with the Group 9 results which showed time as highly interdependent with state variable 2, unorganized violence and with all three harmonic functions of time. The results relating to Groups 4 and 6 exhibited moderate interdependence among time, the planned violence , state variable and its associated harmonic function. This moderate interdependence however, does not suffice to make "time" a predictor of change in planned violence.

Third, it was observed that expectations about factor loading patterns derived from the harmonic analysis were, in every instance, confirmed by the factor analysis.

Many interpretations and conclusions ensuing from the above results may be conveniently discussed within the framework of the hypotheses presented earlier. Again the categories constituting this framework are interdependence of the state variables, interdependence of the time variable and the state variables, and confirmation of the linear form assumptions resulting from the harmonic analysis.

The results on the question of interdependence of the state variables, indicate the efficacy of typologizing nations according to similarities in their time paths. Initially, the justification for typologizing nations in this manner arose from the possibility that differences in nation time paths might be blurring interdependencies among state variables and hypothetical time functions. No evidence was found for this supposition vis-a-vis the specific time functions used in the original over-time analysis. However, if it is recalled that the initial analysis indicated moderate negative interdependence between state variable 2, unorganized violence, and state variable 3, number killed in domestic violence, it is apparent that the results of the above group factor analyses indicate that the initial over-time analysis which did not control for differences in time paths did blur or "wash out" a much more complex picture of linear interdependence among state variables within each time-path-similar group of nations. Thus, between-group differences in patterns of linear interdependence among state variables are quite pronounced, and this provides a strong justification for addition of the step, prior to over-time analysis, of isolation of time-path-similar groups of nations to our quantitative methodology for systems analysis.

The results of the factor analyses relating to the state variable interdependency question also are relevant to the speculation raised previously that the lack of interdependence between planned violence and the other two state variables observed in the initial over-time analysis was best interpreted as disconfirming linear interdependence in this instance rather than functional interdependence in general. Thus, the above results show that planned violence does exhibit linear interdependence with one or the other of the remaining two state variables depending upon which group of nations the analyst is focusing upon. Further, two state variables which exhibited interdependence in the initial analysis often do not do so in the group specific factor analyses just performed. Thus, it is true for all three state variables that observation of linear interdependence among them depends upon the sample of the universe of political systems the analyst focuses upon, and that for substantial subsets of this universe any pair or even all three state variables may be linearly interdependent. This, in turn, suggests that all three state variables are part of the same domestic conflict process as originally hypothesized, and that the functions describing their interrelations are dissimilar. That is, once again, for specific subsets of the universe of nations linear relationships among the state variables prevail, for other subsets linear relationships do not prevail. In these instances non-linear formulations need to be utilized as inputs to the factor analysis in order to demonstrate linear interrelations.

The implication of the results of the analysis relating to the time variable is that this variable is not highly related to over-time variation in the state variables. The inclusion of the time variable alone is not a fair and comprehensive test of the general hypothesis, that simple time functions are highly related to change of system state. It was however a reasonable test given limitations upon our resources. In any event it is clear from the above analysis that time path differences among nations do not, in general, "wash out" linear relationships between state variables and "time". Rather such relationships do not apply even when time path differences are controlled for.

Findings of the factor analyses relating to the harmonic analysis, are once again, completely consistent with it. This demonstrates our major methodological contention that factor analysis can confirm the strength of hypothesized over-time linear relationships when these are, in fact, strong, and can disconfirm them when they are in fact, weak. For reasons outlined in connection with our description of the BMDO4R harmonic analysis program, and also in view of the mathematical character of factor analysis this result was a necessary outcome of our analysis. We chose to explicitly demonstrate it however, in order to provide a concrete illustration of our contention that factor analysis can confirm linear functional forms implicit in non-linear hypotheses about over-time variation.

There are a number of additional conclusions and interpretive issues emerging from the results which do not relate to the three categories of hypotheses previously utilized as a framework for discussion. The first such conclusion is that both harmonic and factor analyses indicate that the harmonic functions were much more successful in providing interpretations of over-time factors than was the variable "time" utilized in the initial over-time analysis. This result, it should be noted, was not a necessary feature of the regression procedure employed in the harmonic analysis. Thus, while the close fit of the harmonic functions emerging from the regression analysis to the average curves of state variable variation over-time was often achieved through expansion of the harmonic function until the number of constants within it reduced the remaining degrees of freedom associated with the average curves from 9 to 2 (that is to say, every regression except one fitted a harmonic function with 7 constants to 9 data points); it also is true that the linear fits between the harmonic functions fitted to the average curves within a group and the data curves for all cases within that group have no necessary connection with this procedure. More directly, the percent of total variation column of Table 9 refers to the proportion of variation in all cases within a group accounted for by the harmonic function fitted to an average data case. This proportion has nothing to do with the proportion measuring the closeness of fit of this function to the variation of the "average" data case itself. The latter proportion is necessarily high due to the regression procedure. The former proportion, upon which our conclusion about the relative success of the harmoni: function in accounting for variance is based, is not determined by the "average" regression, but rather is a function of the total variation in the data of each group of nations analyzed.

Another issue of importance emerging from the factor analysis results concerns the substantive significance of those results over and above the results of the Prior harmonic analysis. Clearly, the correlation and factor analyses independently contributed the conclusions on linear interdependence of state variables and lack of success of the time variable already presented. In addition, the factor analyses also provided knowledge of linear interdependence among the three harmonic functions which was not provided by the prior harmonic analysis. Put another way, assuming dependence of each of the state variables on its corresponding harmonic function and independence of (a) the state variables from each other and (b) time from all other variables; then a minimum of 4 linear terms are necessary to account for a high proportion of the variance in the data matrix utilized in each factor analysis. The factor analyses show, however, that these assumptions are unjustified since in 9 out of 10 groups only 2 terms (factors) were necessary to account for high proportions of variance in the data matrix and in the remaining group only 3 terms were necessary. This knowledge was not available from the harmonic analysis.

On the substantive significance of the time-transition factor analyses a final word is necessary relating to the predictive aspects of the factor model. Examination of the results of the 10 factor analyses reveals that the communality of the 3 state variables, vis-a-vis the time-transition factors, is often greater than the proportion of variance in that state variable explained by a harmonic function. Moreover, the absolute value of such communalities is often in the .70-.85 range. The significance of these observations in light of the fact that the communality denotes the proportion of variance in the variables accounted for by the factors is as follows. First, the factor analyses obviously produces closer fitting models in the sense of variation accounted for than do the harmonic analyses which attempt to fit state variables to harmonics singly. Second, where communalities of the state variables are over .70 there obviously resides in the factor model a capability of prediction of 70% of the variation in state variable values as they change in time. Such prediction, of course, assumes that the factor scores of all relevant cases are already known. Then from the factor loadings and factor scores estimates of state variable values can be derived. There is a major problem involved, however, in estimating factor scores. The problem is that factor scores are linear combinations of all the original data values that were inputs in a specific factor analysis. To compute them precisely therefore, one needs all these original data values. Since it is the essence of prediction to lack all the data values relevant to a problem, and therefore to want to predict these values, it is obvious that the problem extant here lies in the necessity to estimate factor scores from some subset of the variables contributing to the factor analysis and then to use these same estimates to derive new values of the remaining variables related to the factors.

The problem of factor score estimation can be satisfactorily solved if marker variables highly correlated to factors which may be used to estimate variance in the factors exist. It will be noted that such marker variables, and more specifically, many of the time functions utilized above, are often present in the factor analyses (see Appendix B). Since these time functions can be applied at will to yield factor score values for time points not included in the original analysis, it is obvious that the above models contain within them a mathematical capability for generating future predictions. How good the models are at generating predictions we cannot say as no tests of concrete predictions have been performed. Yet if the relationships defined above obtain for corresponding 1967, 1968 or 1969 data then the communalities occurring above indicate that the within-in group variation in one or more of the 3 state variables for the new data will often be predicted with from 70-85% success. In short, we will be well on the way toward specification of laws of system change relative to domestic conflict.

h. Summary of Results of the Illustrative Analysis

In the foregoing pages an illustration of a methodology for quantitative systems analysis was presented. The illustration involved both state variable and over-time analysis of a 666 systems-time-slice by 9 variable matrix of domestic conflict data. The first step in the analysis was correlational and factor analysis of the column standardized domestic conflict data matrix. The result of this analysis was a factor model relating the 9 domestic conflict data variables to 3 state variables or systems-time-slice factors called planned violence, unorganized violence and number killed in domestic violence. Examination of the pattern of factor loadings indicated that these factors were, in general, consistent with those isolated in previous domestic conflict factor analyses by Rummel, Tanter and others. The system-time-slice factor analysis however, was somewhat unsatisfactory in that it only accounted for 55.3% of the variance in the original data variables. However, the analysis was successful from a methodological point of view in that it illustrated the role of factor analysis relative to three problems besetting state variable selection:

(a) empirical specification of abstract state variables;
(b) theoretical economy;
(c) measurement validation.

Following computation of the factor scores or specific values of the domestic conflict factors for each system-time-slice analyzed the illustration proceeded with an analysis of the over-time variation in factor scores. Initial results of this over-time analysis resulted in disconfirmation of a number of hypotheses about the nature of time functions accounting for over-time variation. Reasons were sought for this disconfirmation and a limited investigation was carried out of two possibilities. First, that the initial hypotheses were disconfirmed because of their relatively simple character, and second, that they were disconfirmed because of failure to take into account differences in time paths among groups of nations. The latter possibility led to an attempt to typologize the 74 nations in the data sample according to similarities in their time paths. The former possibility led to an attempt to generate new hypotheses through the technique of harmonic analysis and periodic regression.

Following these analyses new over-time factor analyses were performed on 10 groups of nations having similar time paths. These were quite successful in that expected linear relationships emerging from the harmonic analysis were confirmed thus demonstrating the utility of factor analysis in confirming over-time linear formulations. New information about the interdependencies among state variables and associated harmonic functions and the predictive capabilities of the factor analyses was also provided. In general, it was further concluded that the auxiliary typological harmonic analyses were valuable because they indicated (a) that the initial over-time analysis had "washed out" interdependency relations among the state variables and (b) that the hypotheses utilized in the original analysis probably were too simplistic to describe the complex processes governing over-time variation in domestic conflict. In light of conclusion (a) it was further concluded that typological analysis based on system time-path similarity should be included in the quantitative methodology advocated here.

FOOTNOTES

[1] Some examples are: David Easton, The Political System (1953), David Easton, A Framework for Political Analysis (1965). Karl W. Deutsch, The Nerves of Government (1963). Gabriel A. Almond, "A Functional Approach to Comparative Politics" (1961), Charles C. McClelland, "Systems and History in International Relations: Some Perspectives for Empirical Research and Theory" (1958). Richard N. Rosecrance, Action and Reaction in World Politics (1963), Morton A. Kaplan, System and Process in International Politics (1957).

[2] Cf. Rummel (1965) and Brams (1968).

[3] Thus, Margenau distinguishes 8 major disciplines in Physics: particle mechanics, mechanics of rigid bodies, continuum mechanics, hydro-dynamics, electrodynamics, thermodynamics, statistical mechanics and quantum mechanics. Only statistical mechanics employs a system conception distinguishing more than one component. Cf. Henry Margenau, The Nature of Physical Reality. (1950).

[4] Timothy and Bona (1967), p. 3.

[5] Rudner, (1967), chapter 5.

[6] *Ibid.*, p. 90.

[7] A major respect in which the systems concept presented here differs from other accounts such as those of Boulding (1956), McClelland (1966), Easton (1965), etc. is in the lack of explicit consideration of concepts such as open system, feedback, homeostasis and such. The omission is deliberate. These concepts generally are employed when analysts wish to classify systems theoretically according to the generic type of transition process which characterizes them. This is not our purpose here however. Rather we wish to focus particular attention on the problems of state variable selection and dynamic time-series analysis in general. For this purpose a discussion of distinctions between feedback and non-feedback systems is superfluous.

[8] Cf. Ernest Nagel, The Structure of Science (1961), pp. 278-283.

[9] It should be noted that in the strict sense the above requirement is impossible to fulfill. For given any two variables x and y measured at points in time $(t_1, . . ., t_n)$ it is always possible to write some expression $y = f(x)$ if one is willing to formulate a sufficiently complex relation. The question however, is whether one can write such an expression which makes "theoretical" sense. Given this possibility it is necessary for systems analysis to inquire into the functional independence of hypothetical state variables.

[10] See Morrison (1968) for an account of the component model.

[11] On rotation to orthogonal and oblique simple structure and to other target matrices see Rummel (1969) and Cattell (1966b). Rotation as referred to above need not be orthogonal rotation but may be rotation to oblique simple structure or to a hypothetical matrix.

[12] See Harman (1968), chapter 16 and Rummel (1969), forthcoming, chapter 19.

[13] See Ernest Nagel, The Structure of Science. op. cit., p. 415 on formulation of the conditions for a directively organized system.

[14] Some possibilities of course are sine functions, power functions, log functions, and so on.

[15] On this point see H. T. McAdams, "Regression Models: Facts and Fallacies" (1968).

[16] This is called P-Analysis. See for example, Cattell, "The Data Box: Its Ordering of Total Resources in Terms of Possible Relational Systems", and Cattell, "Patterns of Change: Measurement in Relation to State-Dimension, Trait Change, Lability and Process Concepts", both in Raymond B. Cattell (ed.), Handbook of Multivariate Experimental Psychology (1966).

[17] The method to be described is adopted from some suggestions on "Three Dimensional Factor Analysis" by Rudolph Rummel in his forthcoming Applied Factor Analysis (1969), chapter 8. It should be emphasized however, that Professor Rummel does not agree with this particular application of his suggestions.

[18] The form utilized in reporting factor analysis results is that suggested by Rudolph J. Rummel in his "Understanding Factor Analysis" (1967).

[19] See BMD (1966), pp. 275-288.

[20] The interpretation of the square of the product moment correlation coefficient as equivalent to the ratio of explained variance (by a regression equation) to total variance is quite common. A derivation is given in Blalock (1960), pp. 295-299.

REFERENCES

1. Almond, G.A., "A Functional Approach to Comparative Politics" Gabriel, A.Almond and James S. Coleman (eds.) Politics of the Developing Areas. Princeton: Princeton University Press, 1961.

2. Blalock, Hubert M., Jr., Social Statistics, New York, McGraw Hill, 1960.

3. BMD, Biomedical Computer Programs. Health Sciences Computing Facility, UCLA, Los Angeles, 1966.

4. Borock, Donald C., Dimensions of Domestic and Foreign Conflict, 1964-66. Unpublished Ph.D. dissertation, University of Cincinnati, Cincinnati, Ohio, 1968.

5. Boulding, Kenneth. "General System Theory -- The Skeleton of a Science." Management Science, Vol. II (1956), pp. 197-208.

6. Brams, Steven J., "Measuring the Concentration of Power in Political Systems," American Political Science Review, 62, 1968, 461-475.

7. Cattell, Raymond B., (ed.) Handbook of Multivariate Experimental Psychology, Chicago: Rand McNally, 1966.

8. Cattell, Raymond B., (1966a) "Patterns of Change: Measurement in Relation to State Dimension, Trait Change, Lability and Process Concepts" in Raymond B. Cattell (ed.) Handbook of Multivariate Experimental Psychology Chicago: Rand McNally, 1966.

9. Cattell, Raymond B., (1966b) "The Meaning and Strategic Use of Factor Analysis," in Raymond B. Cattell (ed.) Handbook of Multivariate Experimental Psychology. Chicago: Rand McNally, 1966.

10. Deutsch, Karl W., The Nerves of Government. New York: The Free Press, 1963.

11. Easton, David, The Political System. New York: Alfred A. Knopf, Inc., 1953.

12. Easton, David, A Framework for Political Analysis. Englewood Cliffs, N.J.: Prentice-Hall, 1965.

13. Harman, Harry, Modern Factor Analysis. Chicago: University of Chicago Press, Revised 1967.

14. Kaplan, Morton, A., System and Process in International Politics, New York: Wiley, 1957.

15. McAdams, H.T., "Regression Models: Facts and Fallacies" in Firestone, Joseph M. (ed.) *Intentions Analysis: A Methodological Component of Forecasting International Behavior*. Cornell Aeronautical Laboratory Report No. VQ-2483-G-1, February 1968, prepared for the Office of Research Analysis (ORA) USAF.

16. McClelland, Charles C., "Systems and History in International Relations: Some Perspectives for Empirical Research and Theory" *General Systems Yearbook*, *3*, 1958, pp. 221-47.

17. McClelland, Charles A., *Theory and the International System*, New York: MacMillan, 1966.

18. Margenau, Henry, *The Nature of Physical Reality*. New York: McGraw Hill, 1950.

19. Morrison, Donald F., *Multivariate Statistical Methods*, New York: McGraw Hill, 1967

20. Nagel, Ernest, *The Structure of Science*, New York: Holt, Rinehart, and Winston, 1961.

21. Rosecrance, Richard N., *Action and Reaction in World Politics*. Boston: Little Brown, 1963.

22. Rudner, Richard S., *Philosophy of Social Science*. Englewood Cliffs, N.J.: Prentice-Hall, 1967.

23. Rummel, Rudolph J., "Dimensions of Conflict Behavior Within and Between Nations," *Yearbook of the Society for General Systems Research*, *8*, 1963, 1-50.

24. Rummel, Rudolph, J., "A Field Theory of Social Action With Application to Conflict Within Nations" *Yearbook of the Society for General Systems Research*, *10*, 1965, 183-204.

25. Rummel, Rudolph J., "Dimensions of Conflict Behavior Within Nations 1946-59." *Journal of Conflict Resolution*, *10*, 1966, 65-73.

26. Rummel, Rudolph J., "Understanding Factor Analysis," *The Journal of Conflict Resolution*, *11*, 1967, 444-80.

27. Rummel, Rudolph J., *Applied Factor Analysis*, Evanston, Northwestern University Press, forthcoming (1969).

28. Tanter, Raymond, "Dimensions of Conflict Behavior Within and Between Nations, 1958-60," Ph.D. Dissertation, Bloomington, Indiana, Indiana University, 1964.

29. Timothy, Lamar K., and Bona, Blair E., *State-Space Analysis: An Introduction*, New York: McGraw-Hill, 1967.

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Variables

Nations		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Afg	55									
	56									
	57									
	58						1	1	1	
	62									
	63									
	64									
	65							1		
Afg	66									
Alb	55									
	56						1			5
	57									
	58									
	62									
	63									
	64									
	65									
Alb	66									
Arg	55	3	6		2	3	17	6	3	4279
	56		2	1		1	3	2	1	91
	57		2	1	1	2	5			
	58		4	1	1		1	1	1	9
	62		1	1	6	1	3		4	36
	63		1	1						3
	64		1	2			10	7		14
	65				2	1		2	1	1
Arg	66		2	1	1	1	9	20	2	1
Aul	55									
	56									
	57									
	58									
	62									
	63									
	64									

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Aul	65									
Aul	66						1	6		
Bel	55						2	1		
	56									
	57									
	58			2		1	2	3		1
	62						1	1		
	63		1	1			1	3		
	64									
	65				1		1	1		
Bel	66				1			4		1
Bol	55									
	56	1			1		3			4
	57						2		1	
	58		1	1	1		2		2	115
	62					1	1			8
	63		1	1				1	1	10
	64	2	1	2	2	1	8	5	2	116
	65	2	1			1	9	1	5	171
Bol	66						1			
Bra	55				1	1			1	
	56				1		3	1	2	15
	57	1								
	58	1	1				2		1	3
	62		2		2		4	2		9
	63		1			1	2		4	3
	64			1	2	2	3		3	
	65			2	1	1		5	7	
Bra	66					1	4	7		10
Bul	55									
	56									
	57							1		
	58									
	62					1				

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Variables								
		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Bul	63						1			
	64					1	1			
	65					1			1	
Bul	66									
Bur	55			1					1	122
	56			1					1	100
	57			1					1	46
	58			1	1				1	311
	62			3		1			2	1200
	63			3		1	2		2	1200
	64			2					1	334
	65					1		4	2	153
Bur	66			1						9
Cam	55				1					
	56									
	57									
	58	1		1	1					
	62									
	63			1						10
	64						1			
	65			2						
Cam	66			1						
Can	55									
	56									
	57									
	58						1			1
	62			1			1	1		3
	63			1	1		1			
	64			1				2		2
	65			1			4			
	66	1		1				1		1
Cey	55									
	56						4			10
	57						2			
	58	1	1		1		2	1		282

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		**Variables**								
		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Cey	62									
	63									
	64		1		3					
	65						3		1	
Cey	66				2		3			9
Chl	55				1			1		
	56		1		1	1				
	57						5			
	58		1		1		1			2
	62		1				1			5
	63		1				1		1	
	64							1		
	65		1				2		1	
Chl	66									
Chn	55					1				
	56								2	2000
	57					1	1		1	
	58			1		1	1		1	1521
	62			1			24		1	200
	63								1	100
	64			1		1				103
	65			1	1	1	2		3	
Chn	66						2	2	1	
Cht	55									
	56									
	57						2			
	58				1		1			
	62									
	63									
	64									
	65								1	
Cht	66									
Col	55									
	56	1		1			3	1		463
	57		3			1	8	2	1	103
	58			1	1		2		1	57

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Col	62									2090
	63		1	2	1		4	3		1566
	64			2			2			744
	65			1	1		4			66
Col	66				1		2	5	2	31
Cos	55			1					1	20
	56									
	57									
	58			1						
	62									
	63									
	64									
	65								1	
Cos	66									
Cub	55	1		1			4	7		2
	56	1		1			4	4		190
	57	3	1	1				4		363
	58	1	1	1	2	2	2	1	1	1503
	62			3						500
	63			2				2	0	500
	64			1	2					4
	65			1		3			4	
Cub	66			1		1				2
Cze	55									
	56						1	4		4
	57							1		
	58									1
	62									
	63						1	1		
	64						1			
	65						1			
Cze	66									
Den	55									
	56									
	57									

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations	Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Den 58									
62									
63									
64									
65									
Den 66									
Dom 55									
56									
57									
58	1		1	1	1	1	1	1	51
62						1		1	30
63			2		1	8	2	1	28
64				1		4	6		9
65	1	1	2	2		9	1	5	2684
Dom 66			1			6	3	2	41
Ecu 55					1		1		
56						4		1	1
57									
58				1		3	1		16
62				1		3		1	8
63							2	1	
64			1	1		1	1		
65		1	1		2			1	5
Ecu 66				1	1	8	7		3
Els 55									
56									
57									
58	1			1		1	1	1	1
62									1
63									
64									
65									
Els 66									
Eth 55									
56									
57									

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Variables								
		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Eth	58						1		1	742
	62						1		1	100
	63								1	400
	64		1						1	135
	65									
Eth	66									
Fin	55									
	56									
	57				1					
	58				1			1		
	62							4		
	63									
	64									
	65									
Fin	66									
Frn	55				1			2		
	56				1		5	10		
	57	5			2		4			
	58	1	1	1	1		5	11		13
	62	1	2	2			4	2		
	63		1				4	3	1	
	64			1			1	1		1
	65			1						
Frn	66						1	3		
Gme	55									
	56									
	57									
	58									
	62									
	63									
	64									
	65									
Gme	66									

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Variables							
	Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Gmw 55									
56									
57									
58							1		
62				1		1			
63							1		
64									
65				1					
Gmw 66						3	1		
Grc 55									
56									
57									
58				1		1			
62				1		1			
63				1					
64									
65		1	1	1	1	3	16		1
Grc 66		1		2		3	5		
Gua 55				1			1	1	10
56				1		2	4		8
57	1	6		2		4	1	1	2
58			1	1		2	1	1	1
62				1				2	2
63			1						13
64			2	1					9
65	2		2	2	1				20
Gua 66	1		2	2	1			1	16
Hai 55									
56		7					2	1	
57		5		2		5	2	3	53
58	1		1	1		1	1	1	15
62			2	1	1				200
63			1	1					200
64					1			1	300
65			1		1				60
Hai 66									

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Hon	55									
	56						3		2	37
	57						1		1	1
	58	1		1	1		1		1	67
	62									82
	63			1					1	114
	64									
	65			2	2		2			2
Hon	66									
Hun	55					1				
	56		1		1	1	14	1	1	13389
	57		1		1	1	1			
	58									
	62					1				
	63									
	64									
	65									
Hun	66					1		1		
Ind	55	2	1			1	2	6	1	399
	56	1	5			1	29	8	1	931
	57			1				6	1	342
	58	1	1	1			14	3	1	444
	62					1	4	5	1	514
	63		3				14	4	1	1270
	64	1				1	13	4	1	2840
	65	4	1		1	1	25	5		107
Ind	66		1	2	1		57	12		398
Ins	55			1	1			1	1	4176
	56			1	1				1	
	57	1			1		1	1	1	1
	58	1		1	1		1	1	1	4559
	62						2	2	1	57
	63								1	50
	64				1				1	0
	65			1	2	2	8	3	4	76054
Ins	66				1	1	8	30		80000

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Irn	55	1				1				
	56						1			127
	57									
	58						1	1		1
	62						4	3	1	584
	63									
	64									
	65	2								4
Irn	66									
Irq	55									
	56						15	7		55
	57				1					
	58	2		1	1	1	5	1	2	894
	62					1	1			1655
	63	1					2		5	2477
	64								1	6
	65				1	1			2	
Irq	66	1		1	2				2	18
Ire	55									
	56									
	57									
	58									
	62									
	63							1		
	64									
	65									
Ire	66			1						
Isr	55									
	56						1	1		
	57	1					1			
	58				1		1			
	62							1		
	63						1	1		
	64				1			1		
	65						3	3		
Isr	66						1	1		

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Variables: Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Ita	55					2	2	0		
	56						2			
	57				2					
	58		1	1	1		4	1		2
	62			1			6			9
	63			1	1			1		
	64			2	1			2		17
	65				1		1	2		
Ita	66			1	1		1			6
Jap	55									
	56						3			
	57						1			
	58	1	1		1		5	6		1
	62						1			
	63							1		
	64							8		
	65						2	8		
Jap	66						4	2		
Jor	55				1					
	56		2					2		
	57		1		1	1	3	2	1	
	58	1		1	1	1	1		1	
	62				1		2	4		44
	63									
	64									
	65									
Jor	66				1	1	3.	9		10
Kon	55									
	56									
	57									
	58									
	62									
	63									
	64									
	65									
Kon	66					1				

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Kos	55							1		
	56	2					2			
	57						1			
	58	1			1	1	7	3		98
	62							7		
	63				2		6	10		1
	64				1	1	24	30	1	11
	65			1	1		12	30		15
Kos	66			1				2		9
Leb	55									
	56						2			
	57			1			2			23
	58	3	1	1	1		10	1	1	54
	62									
	63						1			
	64				1		4			1
	65				1					
Leb	66				2	1				
Lbr	55	1								
	56									
	57									
	58									
	62								1	
	63									
	64									
	65									
Lbr	66				1					
Mex	55						2			28
	56									
	57						1			
	58	1	1				6	2		3
	62						1			3
	63						1	1		8
	64						1			
	65			1			1	2		20
Mex	66						2			

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Nep	55							1		28
	56									
	57						1			
	58				1	1			1	2
	62			1						50
	63									
	64									
	65									
Nep	66									
Nth	55									
	56									
	57									
	58				1		1			
	62									
	63									
	64									
	65									
Nth	66				1		6	2		1
New	55									
	56									
	57									
	58									
	62						1			
	63									
	64									
	65									
New	66							2		
Nic	55									
	56	1						1		
	57									
	58	1	1	1	1		1		1	38
	62						2			2
	63									
	64			1				1		
	65									
Nic	66									

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Nor	55									
	56									
	57									
	58									
	62									
	63				1					
	64									
	65									
Nor	66									
Out	55									
	56									
	57									
	58									
	62									
	63									
	64						1			
	65					1				
Out	66									
Pak	55				2	1		1	1	
	56						1			3
	57				2		2			
	58	1			1	1	1		1	2
	62						10	3		133
	63					1	6			1000
	64						7	3		27
	65						2			
Pak	66		1		1		3	1		13
Pan	55	1								
	56						2			
	57									
	58		1	1			1	1	1	4
	62						1			
	63									
	64						2	3		31
	65			2				5		1
Pan	66						7	1		2

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations	Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Par 55					1			3	10
56						1			
57									
58			1	1	1	1	1	1	25
62					1				2
63									
64									
65			1						
Par 66									
Per 55						1			
56		1				6		1	
57									
58				1		1	1	1	1
62		2		2		2	6	3	101
63	1	1				1		2	362
64				2					
65			2	2					285
Per 66			1						1
Phi 55			1		1				
56			1						1
57	1		1						4
58	1		1					1	26
62									
63									
64			2	1					50
65			2			5			110
Phi 66	1		2			2	3		8
Pol 55									
56		1				1	6		140
57						5	3		
58						1			
62									
63						2			
64							1		
65					1				
Pol 66					1	1	2		

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Variables								
		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Por	55									
	56									
	57									
	58						3	1		
	62									
	63							3		
	64							1		
	65			1		1	1	4		
Por	66			1				1		
Rum	55					1				
	56									
	57									
	58									
	62									
	63									
	64									
	65									
Rum	66									
Sau	55									
	56									
	57									
	58				1					
	62									
	63									
	64					1			1	
	65								1	1
Sau	66									

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations						Variables				
		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Spn	55							2		
	56		1				1			
	57						1	1		
	58		1	1	1					7
	62			1						
	63		1	1			1			
	64			1		1		1		
	65						2	7		
Spn	66						7	14		
Swd	55									
	56									
	57				1					
	58									
	62									
	63									
	64									
	65									
Swd	66									
Swz	55									
	56									
	57									
	58									
	62									
	63									
	64			1						
	65									
Swz	66			1						
Tai	55									
	56		1				1			
	57				1			1	1	
	58			1	1				1	2
	62									
	63			1	1					10
	64			2	1				1	
	65			2					1	24
Tai	66			2			1			35

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Variables								
		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
Tur	55				1					
	56							2		
	57						2			
	58				1	1	3	1	1	6
	62						2	2		28
	63	1								1
	64	1			2		1			
	65				1		1			
Tur	66					1				
Uns	55							4		
	56						11	2		14
	57		2			1	6	5		35
	58	1	1	1	1		20	7	1	66
	62			1			2	1		44
	63			1			1	1		
	64			1			1			11
	65			1				1		
	66	1		1			1	2		15
USR	55					1				
	56						1	4		50
	57						2			
	58									
	62						2			212
	63									
	64				1					
	65									
USR	66						1			
UNK	55									
	56							4		
	57						1	1		
	58						4			
	62				1		9	6		
	63			1			3	1		
	64			1			5			
	65			1			4			
UNK	66		1	1	1		2			

APPENDIX A

DOMESTIC CONFLICT - RAW DATA MATRIX

Nations		Variables								
		Assassinations	General Strikes	Guerrilla Wars	Major Govt. Crises	Purges	Riots	Demonstrations	Revolutions	No. Killed in Domestic Violence
USA	55						1	1		
	56						1	1		
	57						2			
	58						10	2		1
	62						31	67		3
	63	1					29	115		12
	64						32	97		8
	65			1			23	208		47
USA	66						40	145		173
URU	55									
	56									
	57									
	58	1								
	62									
	63									
	64				1			1		
	65		1		1		1	3		
URU	66									
VEN	55									
	56						4			20
	57						1	2		2
	58	1	1	1	1	1	8	1	2	157
	62	1		2	2	2	1	1		1451
	63	1		2		1	4			173
	64			2			2			25
	65			2			1	2		32
VEN	66	1		2				1	1	6
YUG	55									
	56									
	57									
	58									
	62									
	63									
	64							1		
	65									
YUG	66					1		1		

APPENDIX B

RESULTS OF OVER-TIME FACTOR ANALYSES GROUPS 1, 3-10, TABLES 13-30

TABLE 13

Correlation Matrix of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 19 Group 1 Nations

(Factor scores were separately standardized for each nation set of sequentially arranged time slices.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	-.44	1.00					
3. Number killed in domestic violence	.32	-.39	1.00				
4. Time	.03	.05	.06	1.00			
5. Planned violence P_I[a]	.15	-.06	.10	.25	1.00		
6. Unorganized violence P_I	-.07	.14	-.00	-.00	-.46	1.00	
7. Number killed P_I	.09	.00	.16	.44	.62	-.00	1.00

[a] Planned violence P_I, unorganized violence P_I, and number killed P_I are the harmonic analysis functions of time whose derivation is described in the preceding section. The Roman numeral indicates that the harmonic functions are those appropriate for Group I.

TABLE 14

Factor Loading* Matrices of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 19 Group 1 Nations

(Factor scores were separately standardized for each nation set of sequentially arranged time slices.)

	Unrotated Factors[a]				Orthogonally rotated factors[b]		
Variables	1	2	3	h^2	1	2	3
1. Planned violence	.49	(.58)	-.07	.59	.06	(.76)	.08
2. Unorganized violence	-.42	(-.71)	-.04	.68	.10	(-.80)	-.14
3. Number killed in domestic violence	.48	(.51)	-.30	.58	.19	(.73)	-.12
4. Time	.47	-.44	-.43	.60	(.76)	-.04	-.14
5. Planned violence P_I	(.77)	-.37	.31	.84	(.63)	.07	(.66)
6. Unorganized violence P_I	-.40	.06	(-.84)	.86	.04	-.04	(-.93)
7. Number killed P_I	(.71)	-.45	-.30	.80	(.89)	.06	.09
Percent total variance	30.6	23.3	16.7	70.6	26.0	25.1	19.5
Percent common variance	43.3	33.0	23.7		36.8	35.5	27.6
Eigenvalues	2.14	1.63	1.17				

* Loadings $\geq |.50|$ are given in parentheses

a. Principal axis method with unities in principal diagonal of correlation matrix

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

TABLE 15

Correlation Matrix of 3 Domestic Conflict
Standardized Factor Score Variables and 4 Time Function Variables
for 8 Group 3 Nations

(Factor scores standardized as appropriate for time-transition analysis.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	-.26	1.00					
3. Number killed in domestic violence	.67	-.20	1.00				
4. Time	.46	-.00	.56	1.00			
5. Planned violence P_{III}	.75	-.23	.60	.67	1.00		
6. Unorganized violence P_{III}	.48	.36	-.31	-.19	-.65	1.00	
7. Number killed P_{III}	.64	-.16	.70	.85	.85	-.44	1.00

TABLE 16

Factor Loading* Matrices of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 8 Group 3 Nations

(Standardization applied to variables appropriate for time-transition analysis.)

Variables	Unrotated Factors[a]			Orthogonally Rotated Factors[b]	
	1	2	h^2	1	2
1. Planned violence	(-.83)	.11	.69	(-.71)	.43
2. Unorganized violence	.31	(-.77)	.70	-.02	(-.83)
3. Number killed in domestic violence	(-.79)	-.13	.64	(-.78)	.19
4. Time	(-.76)	-.48	.81	(-.89)	-.14
5. Planned violence P_{III}	(-.93)	.03	.86	(-.84)	.39
6. Unorganized violence P_{III}	(.62)	(-.54)	.67	.35	(-.74)
7. Number killed P_{III}	(-.92)	-.24	.91	(-.94)	.15
Percent total variance	58.2	17.3	75.5	51.7	23.6
Percent common variance	77.1	22.9		68.5	31.3
Eigenvalues	4.08	1.21			

* Loadings $\geq |.50|$ are given in Parentheses.

a. Principal axis method with unities in principal diagonal of correlation matrix.

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

TABLE 17

Correlation Matrix of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 3 Group 4 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	-.31	1.00					
3. Number killed in domestic violence	.29	-.86	1.00				
4. Time	.48	-.11	.20	1.00			
5. Planned violence P_{IV}	.92	-.34	.31	.48	1.00		
6. Unorganized violence P_{IV}	-.63	.49	-.44	-.26	-.69	1.00	
7. Number killed P_{IV}	.61	-.46	.47	.52	.67	-.93	1.00

TABLE 18

Factor Loading* Matrices of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 3 Group 4 Nations

(Appropriate standardization for time transition analysis was applied to domestic conflict variables.)

	Unrotated Factors[a]			Orthogonally Rotated Factors[b]	
Variables	1	2	h^2	1	2
1. Planned violence	(.82)	.37	.81	(.89)	-.13
2. Unorganized violence	(-.65)	(.70)	.91	-.17	(.94)
3. Number killed in domestic violence	(.64)	(-.69)	.88	.17	(-.92)
4. Time	(.55)	.42	.47	(.69)	.06
5. Planned violence P_{IV}	(.85)	.34	.84	(.90)	-.17
6. Unorganized violence P_{IV}	(-.87)	-.00	.75	(-.73)	.47
7. Number killed P_{IV}	(.90)	.07	.81	(.80)	-.42
Percent total variance	58.3	19.9	78.2	47.3	31.1
Percent common variance	74.6	25.4		60.4	39.7
Eigenvalues	4.08	1.40			

* Loadings $\geq |.50|$ are given in parentheses.

a. Principal axis method with unities in principal diagonal of correlation matrix.

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

TABLE 19

Correlation Matrix of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 5 Group 5 Nations

(Appropriate standarization for time-transition analysis was applied to domestic conflict variables.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	-.57	1.00					
3. Number killed in domestic violence	.43	-.62	1.00				
4. Time	-.21	.30	-.34	1.00			
5. Planned violence P_V	.76	-.39	.26	-.20	1.00		
6. Unorganized violence P_V	-.59	.50	-.45	.43	-.77	1.00	
7. Number killed P_V	.32	-.36	.62	-.35	.42	-.72	1.00

TABLE 20

Factor Loading* Matrices of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 5 Group 5 Natior

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

Variables	Unrotated Factors[a]			Orthogonally Rotated Factors[b]	
	1	2	h^2	1	2
1. Planned violence	(.77)	.45	.80	(.88)	-.18
2. Unorganized violence	(-.73)	.10	.54	-.47	(.56)
3. Number killed in domestic violence	(.71)	-.45	.71	.22	(-.81)
4. Time	(-.50)	.49	.49	-.04	(.70)
5. Planned violence P_V	(.77)	(.55)	.89	(.94)	-.11
6. Unorganized violence P_V	(-.88)	-.11	.79	(-.73)	(.51)
7. Number killed P_V	(.74)	-.31	.65	.34	(-.73)
Percent total variance	54.4	15.4	69.8	36.9	32.9
Percent common variance	77.9	22.1		52.9	49.1
Eigenvalues	3.81	1.07			

* Loadings $\geq |.50|$ are given in parentheses.

a. Principal axis method with unities in principal diagonal of correlation matrix.

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

TABLE 21

Correlation Matrix of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 3 Group 6 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	.41	1.00					
3. Number killed in domestic violence	-.50	.05	1.00				
4. Time	.77	.45	-.43	1.00			
5. Planned violence P_{VI}	.87	.45	-.56	.83	1.00		
6. Unorganized violence P_{VI}	.51	.76	-.04	.61	.59	1.00	
7. Number killed P_{VI}	-.60	-.04	.79	-.38	-.70	-.06	1.00

TABLE 22

Factor Loading* Matrices of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 3 Group 6 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

	Unrotated Factors[a]			Orthogonally Rotated Factors[b]	
Variables	1	2	h^2	1	2
1. Planned violence	(-.90)	-.05	.82	(-.70)	(.57)
2. Unorganized violence	(-.55)	(.69)	.78	.06	(.88)
3. Number killed in domestic violence	(.62)	(.66)	.82	(.90)	.07
4. Time	(-.87)	.14	.77	(-.54)	(.69)
5. Planned violence P_{VI}	(-.96)	-.05	.93	(-.75)	(.61)
6. Unorganized violence P_{VI}	(-.66)	(.65)	.86	-.05	(.93)
7. Number killed P_{VI}	(.68)	(.62)	.86	(.93)	-.00
Percent total variance	58.2	25.1	83.3	43.1	40.2
Percent common variance	69.9	30.1		51.7	48.3
Eigenvalues	4.08	1.75			

* Loadings $\geq |.50|$ are given in parentheses.

a. Principal axis method with unities in principal diagonal of correlation matrix.

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

TABLE 23

Correlation Matrix of 3 Domestic Conflict
Standardized Factor Score Variables and 4 Time Function Variables
for 3 Group 7 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	-.34	1.00					
3. Number killed in domestic violence	.50	-.49	1.00				
4. Time	.12	-.13	-.18	1.00			
5. Planned violence P_{VII}	.70	-.20	.60	.09	1.00		
6. Unorganized violence P_{VII}	-.34	.41	-.54	-.14	-.49	1.00	
7. Number killed P_{VII}	.50	-.27	.85	-.28	.71	-.64	1.00

TABLE 24

Factor Loading* Matrices of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 3 Group 7 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

	Unrotated Factors[a]			Orthogonally Rotated Factors[b]	
Variables	1	2	h^2	1	2
1. Planned violence	(.73)	.21	.57	(.70)	.28
2. Unorganized violence	(-.53)	-.35	.40	(-.50)	-.40
3. Number killed in domestic violence	(.88)	-.21	.81	(.89)	-.12
4. Time	-.03	(.94)	.89	-.12	(.93)
5. Planned violence P_{VII}	(.82)	.06	.68	(.81)	.14
6. Unorganized violence P_{VII}	(-.74)	-.18	.57	(-.72)	-.25
7. Number killed P_{VII}	(.89)	-.35	.91	(.92)	-.26
Percent total variance	51.4	17.8	69.2	51.0	18.2
Percent common variance	74.3	25.7		73.7	26.3
Eigenvalues	3.60	1.25			

* Loadings $\geq |.50|$ are given in parentheses.

a. Principal axis method with unities in principal diagonal of correlation matrix.

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

TABLE 25

Correlation Matrix of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 2 Group 8 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	.55	1.00					
3. Number killed in domestic violence	-.60	-.82	1.00				
4. Time	.22	-.33	.33	1.00			
5. Planned violence P_{VIII}	.86	.63	-.52	.29	1.00		
6. Unorganized violence P_{VIII}	.57	.94	-.82	-.29	.67	1.00	
7. Number killed P_{VIII}	-.53	-.92	.84	.31	-.62	-.98	1.00

TABLE 26

Factor Loading* Matrices of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 2 Group 8 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

	Unrotated Factors[a]			Orthogonally Rotated Factors[b]	
Variables	1	2	h^2	1	2
1. Planned violence	(-.74)	(-.54)	.84	(-.54)	(-.73)
2. Unorganized violence	(-.94)	.18	.91	(-.95)	-.11
3. Number killed in domestic violence	(.89)	-.18	.82	(.90)	.09
4. Time	.22	(-.91)	.87	.48	(-.80)
5. Planned violence P_{VIII}	(-.77)	(-.56)	.92	(-.57)	(-.77)
6. Unorganized violence P_{VIII}	(-.96)	.14	.95	(-.96)	-.15
7. Number killed P_{VIII}	(.95)	-.18	.93	(.96)	.11
Percent total variance	66.9	22.2	89.1	63.0	26.1
Percent common variance	75.1	24.9		70.7	29.3
Eigenvalues	4.68	1.55			

* Loadings $\geq |.50|$ are given in parentheses.

a. Principal axis method with unities in principal diagonal of correlation matrix.

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

TABLE 27

Correlation Matrix of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 3 Group 9 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	-.36	1.00					
3. Number killed in domestic violence	-.65	.06	1.00				
4. Time	-.31	.70	.34	1.00			
5. Planned violence P_{IX}	.45	-.75	-.19	-.76	1.00		
6. Unorganized violence P_{IX}	-.42	.79	.22	.77	-.95	1.00	
7. Number killed P_{IX}	-.22	.55	.36	.90	-.56	.65	1.00

TABLE 28

Factor Loading* Matrices of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 3 Group 9 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

	Unrotated Factors[a]			Orthogonally Rotated Factors[b]	
Variables	1	2	h^2	1	2
1. Planned violence	(.55)	(.69)	.78	.26	(.84)
2. Unorganized violence	(-.82)	.29	.76	(-.87)	-.04
3. Number killed in domestic violence	-.42	(-.84)	.88	-.08	(-.93)
4. Time	(-.91)	.13	.85	(-.89)	-.22
5. Planned violence P_{IX}	(.90)	-.17	.83	.90	.17
6. Unorganized violence P_{IX}	(-.93)	.18	.89	(-.93)	-.18
7. Number killed P_{IX}	(-.80)	.08	.65	(-.78)	-.22
Percent total variance	61.4	19.2	80.6	55.9	24.7
Percent common variance	76.2	23.8		69.4	30.6
Eigenvalues	4.30	1.34			

---

* Loadings $\geq |.50|$ are given in parentheses.

a. Principal axis method with unities in principal diagonal of correlation matrix.

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.

TABLE 29

Correlation Matrix of 3 Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 2 Group 10 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

Variables	1	2	3	4	5	6	7
1. Planned violence	1.00						
2. Unorganized violence	.51	1.00					
3. Number killed in domestic violence	-.69	-.50	1.00				
4. Time	.21	.12	-.28	1.00			
5. Planned violence P_X	.69	.46	-.62	.45	1.00		
6. Unorganized violence P_X	.41	.78	-.53	.22	.60	1.00	
7. Number killed P_X	-.60	-.57	.72	-.49	-.86	-.73	1.00

TABLE 30

Factor Loading* Matrices of Domestic Conflict Standardized Factor Score Variables and 4 Time Function Variables for 2 Group 10 Nations

(Appropriate standardization for time-transition analysis was applied to domestic conflict variables.)

	Unrotated Factors[a]			Orthogonally Rotated Factors[b]	
Variables	1	2	h^2	1	2
1. Planned violence	(-.77)	.04	.60	(-.68)	-.37
2. Unorganized violence	(-.73)	(.50)	.79	(-.89)	.04
3. Number killed in domestic violence	(.81)	-.01	.66	(.70)	.42
4. Time	-.46	(-.78)	.81	.02	(-.90)
5. Planned violence P_X	(-.87)	-.22	.81	(-.63)	(-.64)
6. Unorganized violence P_X	(-.80)	.33	.75	(-.86)	-.14
7. Number killed P_X	(.93)	.14	.88	(.72)	(.60)
Percent total variance	61.0	14.7	75.7	48.5	27.2
Percent common variance	8.06	19.4		64.1	35.9
Eigenvalues	4.27	1.03			

* Loadings $\geq |.50|$ are given in parentheses.

a. Principal axis method with unities in principal diagonal of correlation matrix.

b. Varimax rotation. Factors with eigenvalues less than 1.0 were eliminated from the rotation.